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THE IMPACT OF ITEM MIGRATION IN THE AIR FORCE LOGISTICS COMMAND CONSUMABLES INVENTORY

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Captain, USAF

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One of the basic unwritten assumptions in inventory management is that the items which make up a given management category remain in there indefinitely. However, work by Smith and Gumbert at DESC showed that the categories there are not static, but that there is a large number of items which migrate from one category to another. The object of this research was to determine the level of item migration in the AFLC consumables inventory system. This study has demonstrated that a significant amount of migration is also present there.

Overall, the AFLC inventory system experiences about a ten percent migration per quarter. The annual migration rate could be as high as forty percent (although it typically will be much less than that). Each SMGC has about the same percentage of migrating items, but the ALCs do not. This may be because certain types of items are more prone to migration than others, though this was not addressed in the study.

The analysis also tracked each item in the San Antonio ALC over a twelve quarter period. The items as a whole migrated an average of 1.4 times, even though twenty-five percent of the items did not migrate at all. The time between migrations averaged only 5.6 consecutive quarters. This makes policy evaluation more complicated since many of the items which are normally included in such an evaluation may not have been under the policy's influence as they are assumed to have been and will thus provide misleading information. Overall, the level of migration experience by the system is significant; current methods of policy evaluation must be re-examined in light of this new information on migration.

Preface

The inventory management policies currently in use by the Air Force Logistics Command (AFLC) assume that once an item is categorized it does not change categories. Studies at the Defense Electronic Supply Center and this thesis have shown that items do indeed tend to migrate from one category to another. Not considering this migration in stockage policies and when evaluating those policies may cost the government millions of dollars each year in unnecessary inventory costs.

I would like to thank Mark Fryman and Patti Moore of AFLC who generously provided their time and experience to help make this study a success. A special note of thanks to Mr. Ray Yokel who patiently helped me through many a puzzle on the CREATE computer system. His assistance saved me hours of agonizing at the terminal. I must also thank my advisor, Lt. Col. Palmer Smith for his guidance and insight throughout this project.

Finally, I would like to express my deepest thanks to my wife Laura for her prayers and support throughout this entire ordeal. Words cannot begin to describe how much of a help she was to me during my work on this thesis. I also owe a great deal to our Lord Jesus Christ for His strength and grace during this time. Without these two people, this project would have been next to impossible to complete. It will be good to be able to again give them the attention they both deserve.

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Abstract

One of the basic unwritten assumptions in inventory management is that the items which make up a given management category remain in there indefinitely. However, work by Smith and Gumbert at DESC showed that the categories there are not static, but that there is a large number of items which migrate from one category to another. The object of this research was to determine the level of item migration in the AFLC consumables inventory system. This study has demonstrated that a significant amount of migration is also present there.

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may not have been under the policy's influence as they are assumed to have been and will thus provide misleading information. Overall, the level of migration experience by the system is significant; current methods of policy evaluation must be re-examined in light of this new information on migration.

The Impact of Item Migration on the Air Force Logistics Command Inventory System

I. Introduction

Background

Inventory management is a major portion of any business operation. Business inventories contain the raw materials for the items produced by the company as well as the materials and equipment needed to maintain the working assets of the firm. Inventory managers try to have enough stock on hand to insure that production will not be interrupted because of a lack of raw materials, but not so much that all of the working capital is tied up in the inventory. The decisions of when to order and how much to order must be made in the face of uncertainty stemming from variances in the demand and in the arrival time of an order. Demands for the materials vary both in the time between demands and the quantity demanded. The time between when an order for new material is placed and when it is available for use is referred to as the leadtime for the order.

There are many costs associated with maintaining an inventory. To begin with, there is a cost to place an order, even if it is just the time it takes someone to process the order. Then there is the cost of the material itself. If it is necessary to barrow money in order to purchase the

stock, then the interest on the money barrowed is a cost. Once the inventory arrives, it is necessary to store it in some place until it is ready to be used. Storing the material usually requires some form of expenditure, either in terms of rent or the forfeiture of otherwise productive space. Finally, there is some penalty for not having the material on hand when it is needed. This penalty may be the loss of a sale, a reduced level of support or capability, or the cost of finding a substitute. The object of inventory management is to minimize the likelihood of incurring a shortage penalty, while also minimizing all of the costs of having stock on hand.

The most commonly used analytical model for minimizing the annual cost of maintaining an inventory is the Wilson Economic Order Quantity (EOQ) formula (5:30). Given the ordering cost, holding cost and annual demand, this model will compute the number of units to order (the EOQ). Dividing the annual demand by the EOQ gives the number of orders to be placed in a year. The strength of this model is its simplicity, but that is also one of its weaknesses. For example, this model assumes that demand is constant, but in the real world, this is hardly the case. Even so, this model and its derivatives are widely used and provide usable results.

When the inventory is very large, it has been shown that a small number of items can account for the largest

portion of the dollar volume of the inventory (5:424, 8:182). These inventories are usually divided into and assigned to categories based on the value of the annual demand for the item. The category with highest demand value items receives the highest degree of management attention, and the category containing the low demand items receives the least attention.

The Air Force Logistics Command (AFLC) manages nearly 600,000 items of consumable spares valued at $2 billion (1:1), as well as numerous repairable items in its inventory. Replenishment requirements for nonrecoverable consumption-type items are computed by the AFLC Economic Order Quantity (EOQ) Buy Computation System (D062) system (3:12). The EOQ model used provides a near optimal order quantity for minimizing the average annual cost of the inventory system (5:30-31; 8:79-81).

In order to facilitate the management of this large inventory, each item in it is assigned to a particular Supply Management Grouping Code (SMGC) according to the dollar value of its projected annual demand rate (PADR) (3:12). The stockage policies for individual items are set according to the SMGC the item is in, as is the level of management the items receive. These policies usually assume that an item remains in the same management category indefinitely. However, the items often migrate from one management category to another. This migration can have a very serious effect on the computation of optimal order quanti-

ties, stockage levels, and inventory growth (and therefore on stock fund investment), but little is known about the problem.

A recent Air Force Audit Agency report cited the fact that AFLC is operating under two constraints, minimum procurement cycle period (PCP) policies and under funding, resulting in AFLC's "not achieving the objective of minimized inventory ordering, holding, and stockout costs" (1:iii). The auditors estimated that AFLC may have increased its average inventory investment by at least $90.6 million (1:Tab A, 7). A similar report was filed by the General Accounting Office (GAO) about the Defense Supply Agency (now the Defense Logistics Agency) in 1976 (10). The GAO reported that nearly 1,149,000 items in DSA had annual issues of less than $400 in 1975, and therefore, stated that cost savings could be realized by more use of commerial distribution systems for low use items. This prompted a study by Smith and Gumbert which discovered that there is a large amount of item migration (movement from one management category to another, usually because of changes in demand) within the system at the Defense Electonic Supply Center (DESC) (7). The result of this migration was that the value of the stock on hand in the lowest item category appeared to be much larger than the value of the demand for these items; a closer look at the items which were over stocked revealed that their stock was purchased while the items were in one

of the higher categories, not while they were in the low one (7:SMITH4). When the demand for the items decreased, they migrated down to the lower category, carrying their stock with them, and hence, the appearance of having over-bought. It is believed that a similar migration problem may exist in the AFLC inventory system and may account for part of the AFAA findings.

Item migration is primarily caused by changes in the demand for an item, and as such, it can effect inventory investment in one of two ways. First, it can increase the number of backorders when an item migrates from a lower category to a higher one. Second, it can increase the amount of excess stock when an item migrates from a higher category to a lower one. This is beceuse upward migration implies an unanticipated increase in demands and downward migration implies an unanticipated decrease in demands.

Problem Statement

The level of item migration in the AFLC inventory system is unknown and has not been included in any inventory control policy. By neglecting this situation, AFLC may have unknowingly increased its inventory costs. Thus, it is necessary to determine the level of item migration under the current system and to determine what effects this has on inventory costs. New stockage policies which consider item migration must then be developed, if migration is indeed a problem.

Research Question

What effect, if any, does item migration have on stockage policies, inventory growth, and the dollar value of investments in the AFLC inventory system?

Scope

The AFLC inventory system includes both nonrecoverable and recoverable items, each governed by a different management system because of the different natures of the items. Since the volume of data which needs to be processed for each of these is very great, this study will concern itself only with the nonrecoverable system. However, the techniques used to investigate migration in one system should equally apply in the other.

A detailed evaluation of the effects of item migration on stockage policies will not be conducted by this study. Such a task would require the use of a detailed inventory simulation model. While such models are available, they are somewhat difficult to use and would require too much time to validate the results. Thus, this study will perform a more deductive policy evaluation using the results of previous migration studies as guides to identifying the symptoms.

Literature Review

Smith and Gumbert. The paper by Smith and Gumbert (7) is the principle reference on migration in large inventory systems. This paper is the report of a study conducted at the Defense Electronics Supply Center (DESC), which is part of the Defense Logistics Agency (DLA). The study determined that even though the number of items in a given management category remained the same from one period to the next, there is a different mix of items each time because of the amount of item movement in the system. Smith and Gumbert called this movement item migration and tried to determine the causes of it. They found out that more than 95 percent of the migration was due to changes in demand or changes in price and demand; whereas, less than 4 percent was due to price changes alone.

This study also discovered that the likelihood that an item would remain in its current category increased the longer it remained there. That is, the longer an item was in the same category, the more likely it was to remain there. This suggests that there may be a need for stockage policies which take into consideration the time an item has been in the same category. Another important finding of the study was that the apparent long supply in the low category was from stock that had actually been purchased in a higher category. Similarly, there were a greater number of back-orders associated with upward migrating items than with

stable items. This is caused by the combination of a lag in the true requirements with respect to the quarterly forecasted demand and the increase in lead time as the item migrates upward (7:SMITH6).

<u>Hobson and Kirchoff</u>. This thesis extends the work done by Smith and Gumbert on migration at DESC (6). The purpose of this thesis was to determine whether or not migration patterns could be modelled as a Markov chain. Hobson and Kirchoff used essentially the same DESC data as did Smith and Gumbert plus the data that have become available since the earlier study was completed. The later study confirmed the results obtained by Smith and Gumbert, but was unable to develop a Markov chain which modelled the system. This was because the system is not stationary. An attempt at dividing the population into two subgroups in an effort to find a more stationary sample also failed to develop a Markov chain. Nonetheless, the effort did do much to further the understanding of the migration process. In particular, this study was able to show that the population could be divided into two subgroups, one of relatively stable items and the other of the less stable ones. This information might be used to develop different stockage policies for the two subgroups.

<u>Diaz</u>. This thesis considered the change made by AFLC which increased the minimum buy quantity to six months worth of demand from DOD requirement of three months worth (4).

This means that each order made must be large enough to satisfy the current demand for at least six months regardless of what the computed optimum EOQ is. (The minimum buy quantity has since been increased to one year's worth of demand). The motivation for this study was an audit conducted by the Air Force Audit Agency. While this study did not directly address the migration problem, it considers a problem which might be exacerbated by migration. One of the findings of the study was that increasing the procurement cycle period (PCP) did cause the value of long supply to increase significantly, confirming the audit report (4:60).

Regulation AFLCR 57-6. This regulation is entitled "Requirements Procedures for Economic Order Quantity (EOQ) Items" (3). It establishes policy and procedures for computing requirements for EOQ items and provides guidance for maintaining the EOQ Buy Budget Computation System (D062). This document furnishes the basic definitions for the terms used in the AFLC D062 system.

Inventory Theory Textbooks. Two textbooks on inventory theory and management were used in the course of this study. The first book was Analysis of Inventory Systems by G. Hadley and T. M. Whitin (5). This book is one of the best sources for classical inventory theory. It contains a detailed development of the economic order quantity (EOQ) equation and the assumptions used to develop the equation. Hadley and Whitin also develop extensions to the basic EOQ model, which try to account for non-deterministic demands,

non-constant lead times, as well as other factors which violate the assumptions of the basic EOQ model. The second book is called Inventory Control: Theory and Practice by Martin K. Starr and David W. Miller (8). This book covers essentially the same material as does Hadley and Whitin, but offers a different perspective on the subject. The two books compliment one-another quite well.

Overview

Chapter II contains a discussion on the AFLC inventory system. A brief description of the five Air Logistics Centers (ALCs) is given, a closer examination of the different supply management grouping codes is presented, and a brief description of the computations used in the D062 system is presented.

Chapter III describes the methodology used to determine the degree of item migration in the AFLC inventory system. It includes a discussion on the construction of the data base, and the analysis approach that was used. A description of the statistical tests employed is also presented.

Chapter IV presents the results of the analysis.

Finally, Chapter V summarizes the project and provides some conclusions drawn from the results. Recommendations for further study are given.

II. AFLC Inventory System

Introduction

The Air Force Logistics Command (AFLC) has the responsibility of providing the critical logistics support for the combat and support elements of the United States Air Force. Each item managed within AFLC is assigned to one of the five AFLC Air Logistics Centers (ALCs). Item managers at each of the ALCs are responsible for computing replenishment requirements for all centrally procured items.

The nearly 600,000 item Air Force consumables inventory would be impossible to manage if done without the aid of computers. The main system used by AFLC for consumable item management is called the EOQ Buy Budget Computation System, the D062 system. This system maintains all of the information and provides all of the computations needed to manage the inventory. The information that it uses comes from the five ALCs and various other data systems. To further enhance the efficiency of management of the system, each item is categorized into a particular Supply Management Grouping Code (SMGC) based on its expected annual demand value. This chapter discusses the SMGCs and their use in the D062 system.

This chapter does not present a detailed discussion on EOQ theory; this is more than adequately covered in other treatments of the subject (4, 5, 8). Instead, it provides

an introduction to the particular implementation used by AFLC and its departures from the classical theory.

AFLC Air Logistics Centers

AFLC is a large organization composed of five Air Logistics Centers (ALCs), each of which manages a unique portion of the total AFLC inventory. Table 2.1 presents the names of the ALCs and their locations and Appendix E lists the major systems and components maintained at each ALC. An item is assigned to only one ALC for management. Each ALC preperes reports on its own inventory holdings for Headquarters AFLC, which then summarizes these in a single set of reports on the total Air Force inventory.

TABLE 2.1

AFLC Air Logistics Centers

ALC	Symbol	Location	FY85 Funds ($M)[1]
Oklahoma City	OC	Tinker AFB, OK	6,944
Ogden	OO	Hill AFB, UT	5,970
San Antonio	SA	Kelly AFB, TX	13,327
Sacramento	SM	McClellan AFB, CA	3,448
Warner-Robbins	WR	Robbins AFB, GA	7,046

1. Source: Command Information Digest (2)

Supply Management Grouping Codes (SMGC)

Studies have shown that the items in large inventory systems can be stratified into different groups based on the dollar value of demand of the item (5:424, 8:182). In the AFLC system, an item is assigned to a Supply Management

Grouping Code (SMGC) based on its annual dollar demand value. During the period covered by the study, there were four categories, labelled X, T, P, and M (from low to high), but since December 1984, there are only three, T, P, M. This study only considers the older data with four categories. Table 2.2 summarizes the break-points between the categories.

TABLE 2.2

Supply Management Grouping Code Break-points

Category Code	Old Range[1]	New Range[2]
X	\$0 to \$500	N/A
T	\$500.01 to \$5000	\$0 to \$2500
P	\$5000.01 to \$50000	\$2500.01 to \$50000
M	over \$50000	over \$50000

1. Before December 1984
2. After December 1984

The SMGC that an item is in denotes the degree of management intensity required for that item. For example, an item in SMGC X receives a low degree of management intensity, whereas an item in SMGC M receives a very high degree, with special emphasis on accuracy, completeness, and timeliness of input data (3:12). As is described below, the SMGC that an item is in also determines the demands used in computing the optimum order quantity, as well as the re-order level, termination level, and lag time. If the annual demand value of an item exceeds the upper bound of its category by

at least $100 for three months, it is automatically re-assigned to a higher category, with a similar action for being under the lower limit. This is, by definition, item migration.

When an item is re-assigned to another SMGC, it is also assigned to a new item manager. A new re-order point, data level, termination level, and safety level are also computed. Thus, if an item moves often, there is a lot of peripheral actions which must be accomplished besides simply noting the change in status.

<u>EOQ Buy Budget Computation System (D062)</u>

According to AFLC Regulation 57-6, "The main function of the D062 system is to compute requirements on nonrecoverable items under the jurisdiction of the Air Force" (3:32). The objective of the system is "to provide all levels of management with the tools needed to make logistics decisions within the scope of the system" (3:32). The system computes the wholesale stock levels and the material requirements for all centrally acquired items with particular expendability, recoverability, and repairability codes (ERRC). To accomplish this, the system uses a model based on the classical Wilson Lot Size formula to compute the economic order quantity (EOQ).

The demands used in computation of the EOQ are actually the average of the past eight quarters demand (if the item

has not been in the system for eight quarters, then estimates are used), multiplied by the peacetime program ratio (PPR). The PPR takes into account programmed flying hours for those items which have demands tied to flying activity such as fuel and oil. In addition, a different set of demand elements is used for the lower two SMGCs than for the higher two. For items in X or T, the demands used are the sum of sales, transfer, and nonrecurring demands, whereas those items in P and M use the sum of sales and transfer demands netted by the sum of sales returns and transfer returns (3:78). For items which are a part of an interchangeability and substitution (I&S) family, all demands and returns are consolidated to the I&S master; the master item's actual unit price and leadtimes are used instead of the family members' individual data (3:78).

Because demands are not constant as is assumed in classical inventory theory, AFLC uses a variable safety level to insure that there is enough stock to cover the expected leadtime demands. The safety level is the number of standard deviations worth of demands to allow on a particular item. The formula which computes the number of standard deviations to be used (denoted as K) is quite complex, incorporating a number of different variables, as seen in figure 2.1.

The standard deviation is computed by first determining the mean absolute deviation (MAD), which "is the average over the base period of the absolute difference between each

quarter's actual net recurring demands and the quarterly average (3 * MDR)" (3:80). The standard deviation is then computed as follows:

$$S.D. = 0.85*(PPR) * 0.5945*MAD * (.82375 * .42625*Leadtime) \qquad (2.1)$$

where PPR is the peacetime program ratio, the constant 0.5945 converts the quarterly MAD to a monthly MAD, and the constants 0.82375 and 0.42625 express the variance (MAD) over leadtime (3:80).

$$K = -0.707 \ln \left[\frac{2\sqrt{2} * HC * Q * UC}{SF * (1/\sqrt{R}) * SD * (1-\exp(-\sqrt{2}*Q/SD))} \right]$$

where: HC = Holding Cost
Q = Demands EOQ
UC = Actual Unit Cost
SF = Implied Shortage Factor
R = Average Requisition Size
SD = Standard Deviation of Leadtime Demands
exp, ln = exponential and natural log functions

Figure 2.1 Formula for K in Safety Level Equation

Minimum Buy Quantity

While the AFLC EOQ Buy Computation System is based on the economic lot size equation, constraints exist in the system which significantly influence what quantity of an item is actually procured. The most important of these constraints is the minimum buy quantity. DODI 4140.39 specifies that a procurement cycle minimum of three months and a maximum of three years will be used to adjust the optimum

EOQ quantity (9:encl 2 p 3). This means that if the optimum quantity to buy is computed to be a single months worth of the item (based on current demand), DODI 4140.39 specifies that three months be procured instead. The purpose of this is to reduce the total number of orders (and the associated manpower) that need to placed for each item. However, AFLC has increased the minimum PCP to one year to further reduce the number of orders generated. A full discussion of the general impacts of this policy on the overall inventory system can be found in the thesis by Diaz (4).

The importance of the minimum PCP to migration is that items temporarily migrating from a lower category to a high one would be forced to order much more stock than they may be able to use once they migrate back down to their original level. When the item moves back down, it will carry all of the new stock it did not use as excess. The amount of excess stock which will be carried will depend on the starting category of the item, the category the order was placed in, and how long the item was in the higher category (ie, how much stock was used).

Summary

AFLC maintains an extremely large and complex inventory system, and as such, has had to depart from the classical inventory control theory to manage it. The most serious departure is the establishment of a large minimum buy quantity; in essence, high demand item buys can no longer be

considered to be computed by the economic ordering formula. This has serious implications for items which migrate up from a lower category only to later migrate back down.

III. Research Methodology

Introduction

This chapter discusses the construction of the data base used in this project (and the associated problems), and the approach used to analyze the data and inventory policies. The study covers the fourth quarter of 1980 to the first quarter of 1985, numbered in the study as Q02 to Q19 (Q01, third quarter of 1980, is not used because only the data for one ALC is available). Since only a portion of the data on the AFLC master tapes for each ALC is needed, project tapes (and their backups) are created with only the information needed. The approach used to evaluate the data is described and some considerations for evaluating migration effects on policy are discussed.

Data Base Construction

The D062 Buy Computation System at AFLC maintains very detailed data tape records on the inventory position of each ALC by quarter. The CREATE computer system at AFLC is used to perform all of the required data extraction and much of the analysis for the study. This system has numerous tape drives and a very large disk capacity, thus allowing a number of jobs to be executed at the same time. Even so, extracting the data is a very time consuming process because of the nearly 600,000 records (per quarter) which need to be

processed.

Data Base Description. All of the data used on this project is extracted from the AFLC EOQ history data tapes. Each record on the history tapes is 1600 bytes long and includes detailed information about each item in the inventory. Because of the size of the records, the data for a single quarter may occupy as many as twenty-five tapes. Reading the data from these tapes takes five to six hours for each quarter, mostly because the few important pieces of information must be separated from the unneeded. Thus, in order to simplify matters, a set of tapes is created to contain just the data elements needed for this project. This new set of tapes can store the data for an entire quarter on a single tape, thereby reducing the number of tapes which need to be processed. Appendix A gives the record structure of the project tapes.

The project data tapes are created by a FORTRAN program which reads a record from the EOQ Master tape, extracts the data of interest, reformats it and copies it back out to the project tape (see Appendix B for the program listing). The program was written so that it would work for any quarter and any ALC by using the Job Control Language (JCL) to set up the specific files to be used. A listing of the program and a sample of the JCL which used it can be found in Appendix B. After a tape was created, it was sorted by federal stock class and identification number. (The EOQ master tapes are already supposed to be sorted this way, but early

analysis of the data indicated that many items were out of order.)

Once the project tapes were created, another tape was built which has the data in a format to facilitate time-dependent migration analysis. This tape, called the Migration Data Tape (MDT), contains a record for each item that was ever in the San Antonio ALC during the course of the study. San Antonio was chosen because it has the longest data run not broken by missing data. It also had the second highest amount of migration of the five ALCs, so the results will show the worst case migration for the system (Warner-Robbins ALC had the highest, but it had too many missing quarters to be useful). Each record starts with the stock number of the item, then contains the ALC, SMGC, unit price, and PMDR of the item for twelve consecutive quarters. The record structure for this tape is shown in Appendix A.

Two programs are used to create the migration data tape (MDT). The first program is used to put the data for the first quarter into the 12 quarter format used on the tape; the quarters yet to be used are filled with "Z"s which indicate missing data. The second program reads a record from the new quarter being added, and compares it to a record from the current MDT. If the stock numbers of the next item of both files match, then the data for the new quarter is simply added to the current MDT record and the record is written to the new MDT file. If instead the new quarter

comes before the current MDT record, then this indicates that this is a new item in the system. A new MDT record is created with all of the quarters first filled with Zs, then the data added for the current quarter. This new record is then written out to the new MDT file. If the new quarter record comes after the current MDT record, then this indicates that the current MDT item has left the system. Because each of the quarters in a record is filled with "Z"s when it was created, nothing more needs to be done to the record, and it is written back out to the new MDT file. Figure 3.1 illustrates the logic just discussed. The listings of the programs discussed here can be found in Appendix B.

Case A

Qtr N		Qtr N+1
1	Match	1
2	Match	2
3	<	4
4		5
5		6

3 < 4 ->
Item 3 left system

Read next record from
Qtr N only:

Qtr N		Qtr N+1
4	Match	4
5	Match	5
	.	
	.	
	.	

Case B

Qtr N		Qtr N+1
1	Match	1
2	Match	2
4	>	3
5		4
6		5

4 > 3 ->
Item 3 entered system

Read next record from
Qtr N+1 only:

Qtr N		Qtr N+1
4	Match	4
5	Match	5
	.	
	.	
	.	

Figure 3.1 Illustration of Matching Algorithm

Many problems were encountered while trying to construct the project data tapes. The majority of the problems stem from the low priority that systems analysis is given by AFLC. The primary problem is missing tapes. Each of the ALCs has at least one tape missing during the period of the study, by far the worst one being Warner-Robbins ALC with tapes missing in eight (out of 19) quarters. In all, there are 16 tapes missing. The second problem is unreadable tapes. Only Oklahoma City ALC and Ogden ALC do not have any unreadable tapes; whereas, the other three ALCs have one bad tape each. Figure 3.2 summarizes the final status of the AFLC EOQ historical data tapes. Another problem encountered is that the EOQ Master files are not correctly sorted. This is solved by resorting after the project files are created (One note on sorting -- sorting should only be done on the federal stock class (FSC) and the national item identification number (NIIN) fields without including the material management code MMC field). Lastly, one quarter of Oklahoma City data is useless (most of the elements contain zeros, even non-numeric elements).

Collecting Migration Data. The project data tapes and the migration data tape are used to build one-step migration tables and collect time-dependent data, respectively. The one-step migration tables record the number of items which migrate from one category to another for each quarter. Time-dependent data include such things as the number of quarters a given item is in a given SMGC.

Quarter

```
         1111111111
ALC  1234567890123456789

OC   mXXXXXXXXXXbXXXXXXX
OO   mXXXXXXXXmXXXXXXXXX
SA   rXmXXXXXXXXXXXXmXXm
SM   XXXXXXrXXXXXXXXmXXX
WR   mmXXXmXXXmrmXmmXXmX
```

Where:

X = tape ok
b = data bad
m = missing tape
r = unreadable tape

Figure 3.2. Final Tape Status Map

To build the one-step migration tables, the data in one quarter are matched to that of the next quarter using the program MATCHxx listed in Appendix B. The logic used to match the records is the same as that described by Figure 3.1, except that the entering and leaving records were only counted and not written out to a file. To count the migrations, an array is set up to hold the count of the number of items migrating from one SMGC to another (including the number of items "migrating" to themselves; that is, not migrating at all). This is done by simply writing a function which returns an index (an integer) for the SMGC value (a character) passed to it, then using the function as the array parameters. Thus, the code to increment the counter which represents the migration from quarter A to quarter B is simply:

```
MIGRATE(INDEX(ASMGC),INDEX(BSMGC)) =
        MIGRATE(INDEX(ASMGC),INDEX(BSMGC)) + 1
```

where MIGRATE is dimensioned as a 5X5 array (for the four

categories and entering/leaving records), INDEX is the indexing function, and ASMGC and BSMGC indicate which category the current item was in at the end of quarters A and B, respectively. By convention, an item goes from A to B.

Other counts maintained by the program includes the number of items drawn from each file (A and B), as well as the number of unique items processed. This number can be used to determine the amount of movement in and out of the system that was experienced between the two quarters. Also recorded is the number of items which are in each SMGC for each quarter. The program outputs a report which lists each of these items, as well as two indexes computed as described below. A sample of this report is shown in Figure 3.3.

```
                  ****  MIGRATION REPORT  ****
                         Quarter 13 to 14
                              ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A =   98945
NUMBER OF RECORDS PROCESSED FROM FILE B =   90689
TOTAL NUMBER OF ITEMS =  100828
MISMATCH INDEX        =   0.02076

BY SMGC IN A         72292   15913    8664    2076
BY SMGC IN B         63349   16349    8847    2145

FROM\TO    X       T       P       M      OUT
 X       60792    1801     162      10    9527
 T         692   13930     879       5     407
 P          33     585    7624     246     176
 M           4       4     162    1878      28
 IN       1829      28      20       6       0

MIGRATION INDEX BY SMGC:

          X          T          P          M         AVG
       0.84092    0.87538    0.87996    0.90462    0.87522
```

Fig. 3.3 Sample Quarterly Migration Report

The two indexes referred to above are the migration index and the mismatch index. Both of these indicate the deviation from a hypothetical "ideal" situation, using a scale of zero to one, with the ideal being at one for the migration index and at zero for the mismatch index. The migration index is the ratio of the number of items which remained in a given category to the number of items in that the category started with in quarter A. Mathematically, this would be (for SMGC X):

$$\frac{\text{\# of items remaining in SMGC X}}{\text{\# of items in SMGC X for quarter A}} \qquad (3.1)$$

Thus, for this index to equal one (its "ideal"), there can be no migration of items into or out of a given category. A value of zero would indicate that none of the items remained in their original category. When migration does occur, this index indicates the fraction that <u>remain</u> in the same category. Typically, the index has a value of 0.85 to 0.95.

The second index computed, the mismatch index, is an indication of the number "mismatches" between the items in the one quarter to the items in the other. It is computed by dividing the difference of the larger of the total number of items in quarters A and B and the number of unique items by the smaller of the two numbers. Mathematically, this would be

$$\frac{\text{(\# of unique items)} - \max\text{ (\# in qtr A, \# in qtr B)}}{\min\text{ of (\# in qtr A, \# in qtr B)}} \qquad (3.2)$$

The "ideal" value for this index is zero, indicating that every item in the one quarter had a match in the second, except for those necessary to account for the difference in the sizes of the two files. A value of one would indicate that none of the items matched at all. Typical values for this index are 0.005 to 0.02. Both the migration index and the mismatch index are printed out in the migration report as shown in Figure 3.3 above.

Time-dependent data are collected using the migration data tape (MDT). The MDT has a record for each item which was ever in the San Antonio ALC during a three year period starting in 1981. The FORTRAN program MIGSTATA was written to scan each record and collect statistics such as the following items:

1. The number of items which were always in the system, the number which enter then leave, and the number which leave and return;
2. The mean, variance, and standard deviation of the number of migrations per item;
3. The mean, variance, and standard deviation of the number of quarters in the system, in a given SMGC, and in each particular SMGC;
4. Frequency counts of item migration and quarters in any SMGC.

In addition, those items which experience more than four migrations in the three year period, as well as those which move in and out the system, are written out to tape files

for later examination. The program listing can be found in Appendix B, and Appendix C contains the full report generated by this program.

As with the one-step migration matrices, migrations are identified by a change in SMGC. An item not in the system has an "SMGC" of "Z". The program reads a record (which represents a single item) and "scans" each SMGC (one for each quarter), incrementing a counter each time the next SMGC is the same as the current one. If the SMGC changes, then statistics are collected and the counter is reset. This routine counts the number of migrations made by the item and the amount of time (in quarters) the item spends in a particular SMGC. The program then looks to see if the item enters, then leaves (or leaves, then re-enters) the system. If it does, the item's record is written out to a file and a counter is incremented. The program collects more statistics, then loops back to get another record. It finishes by preparing the data for output and writing the report.

The program uses the Method of Provisional Means to compute the mean and variance of the various data items of interest. This method can compute these values with only one pass through the data and can be more accurate than the more traditional methods. This is particularly useful in this program, since there are nearly 200,000 records processed by it. The algorithm is shown in Figure 3.4.

Another program which uses the MDT data is called MIGSTATB. This program divides the data into two groups, HIGH and LOW. The HIGH group contains all of the items from SMGCs P and M; whereas, the LOW group contains the items from the categories X and T. MIGSTATB performs two tasks. First, it counts the number of items which migrate from LOW to HIGH sometime during the twelve quarters. Second, for each category, it determines the number of items originally remaining there in the Nth quarter. In this second task, if an item leaves the category at any time during the twelve quarters, it is no longer considered, even if it migrates back.

In the provisional means algorithm, the mean and the sum of the squared deviations are computed recursively as:

$$COUNT_n = COUNT_{n-1} + 1$$

$$D_n = X_n - MEAN_{n-1}$$

$$MEAN_n = MEAN_{n-1} + D_n/COUNT_n$$

$$VAR_n = VAR_{n-1} + D_n(X_n - MEAN_n)$$

where

$COUNT_n$ is the number of the first n cases

$MEAN_n$ is the mean of the first n cases

VAR_n is the sum of squared deviations for the first n cases

The estimate of the mean is $MEAN_N$ and the the estimate of the variance is $VAR_N/[(N-1)/N]$

Fig. 3.4. Method of Provisional Means

Data Analysis Approach

The analysis performed on the data is primarily based on the descriptive statistics generated by the programs described above. The first task is to determine just how much migration is being experienced in the system, and then to try to identify any trends or patterns in the migration detected. The amount of migration is determined from the one-step migration tables and the time-dependent data analysis. Identifying patterns requires the use of techniques such as ANOVA along with the information produced directly from the data tapes. Because of the nature of the system being studied, a certain amount of qualitative analysis is also conducted.

Statistical Analysis of Migration. In order to gain a quick understanding of the levels of migration within the AFLC inventory system, the two indexes described above (the migration index and the mismatch index) are defined. These quickly summarize the level of migration being experienced in the inventory and they provide summary statistics suitable for such techniques as ANOVA. The time-dependent data also provide a number of simple statistics as mentioned earlier.

ANOVA is used to gain an understanding of the interrelationships between the factors involved. The two factors considered are the SMGCs and the ALCs. The goal of this analysis is to determine whether or not there are any sig-

nificant differences among the ALCs and among the SMGCs, and if there are any significant interactions. A significant difference among the ALCs might indicate that the type of product that they handle has different migration patterns or that policies are being implemented differently in one ALC than in another. If a particular class of material was subject to above average migrations, any policy changes might need to reflect that. Similarly, differences among the SMGCs could also influence future policies (the different categories already have tailored policies, so this would not be difficult to implement). It is important to note that while ANOVA may identify differences among the various factor levels, it cannot identify the cause of those differences. This will be left to a more qualitative analysis of the differences.

One of the observations Smith and Gumbert made was that although the number of items in a particular category at any given time appeared to be somewhat constant, the items in the system may be very different from one period to the next (7:SMITH3). Therefore, the quarterly migration tables can only tell part of the story. Migration caused by items which change categories only once and then remain forever would have different policy implications than migration caused by items which often move back and forth between the categories. Smith and Gumbert found extremely little of this type of migration in their study at DESC.

Qualitative Analysis of Migration. Migration is like alcohol: a little may be tolerable in some situations, but a lot of it is usually harmful at best. The point at which migration goes from tolerable to unacceptable is not hard and fast; it will depend very much on the judgement of the decision maker faced with the problem. Therefore, this study will present the level of migration in many different formats in order to help the decision maker determine if the levels found are merely troublesome, or if they represent a real problem which needs immediate attention.

Policy Evaluation

In order to fully determine the effects of migration on a given policy, it is necessary to simulate the system under the different policies, taking into account item migration. Unfortunately, this study did not have time to complete such an analysis. Instead, the results and recommendations of previous studies will be compared to the results found in this study to see if they may be applicable.

Summary

This chapter has described the methods used to extract the project data from the EOQ master tapes and format it to be used by the various analysis programs in the study. The analysis approach was discussed and the techniques to be applied were described. The next chapter presents the results of the analysis performed.

IV. Analysis Results

Introduction

This chapter presents the results of the various investigations conducted on the AFLC EOQ data discussed in the previous chapter. This study found a significant amount of migration within the AFLC inventory system. In order to gain as much insight into the problem as possible, the indications of migration will be presented in a number of different ways. Summary statistics computed in the study are presented with their interpretations. These are then broken down by ALC and SMGC, where applicable. The results of the time-dependent migration analysis are presented next with a discussion on their significance. Lastly, other considerations about the data are presented.

Migration Index Statistics

The migration index discussed in Chapter 3 provides a quick assessment of the level of migration the system experiences between any two periods. It represents the percent of items which did <u>not</u> migrate that period; therefore, it is a good indicator of the item stability in the system. The index used in this study is a <u>quarterly</u> index. An index value of 0.90 means that 90 percent of the items originally in the particular category in the last quarter remained there the following quarter. If the value of the index is

0.95 for four quarters in a row and none of the items which migrate out of the category migrate back in, then the annual index value would be $(0.90)^4$ or 0.6561, indicating that only about 66 percent of the items in the category were still present after a year. Typically, the annual index value is less than the product of the associated quarterly indexes, since some items migrate back into their original category.

Because it is a dimensionless number, the migration index can be compared between the various ALC's and SMGC's to see if any significant differences exist. Table 4.1 summarizes the migration index values for the quarters examined in this study. These values were obtained with the BMDP 4V Multivariate Analysis of Variance program. Overall, the mean quarterly migration index was 0.8991 indicating that, on the average, about 90 percent of the items in any given category do not migrate each quarter.

Table 4.2 presents the 95 percent confidence intervals for the grand mean and the ALC means, and Figure 4.1 presents the same information graphically. The grand mean for the system lies between 0.885 and 0.914. This corresponds to a 0.61 to 0.70 annual index value (assuming that items do not migrate back into their original categories), implying that as many as 30 to 39 percent of the items in the system migrate each year.

From Table 4.1, one can also get the overall mean index value for each ALC. Oklahoma City (OC) and Ogden (OO) have similar index values, Sacramento (SM) has a slightly lower

value, followed by San Antonio (SA) and Warner-Robbins (WR). These last two also have much higher variances than do the first three. The confidence intervals in Table 4.2 and Figure 4.1 show that the difference between the San Antonio index (SA) and the OC, OO, and SM indexes is statistically significant, even with the higher variance (this is because the interval for SA does not overlap the intervals for OC, OO, or SM). The interval for Warner-Robbins is so large because of the small sample size combined with the high variance.

While this difference between the ALCs is significant, it is unclear why this is so. One possible cause may have to do with the mix of systems and components managed by the ALCs. If this is the case, then a study should be conducted to see if the item stock classes can be grouped in terms of their propensity to migrate. If this can be done, then the cause for such a tendency should be identified. It may be necessary to develop new policies which take this tendency into account if it cannot be corrected.

TABLE 4.1

Summary Migration Index Statistics

ALC	SMGC	Sample Size	Mean	Std Dev
ALL	ALL	168	0.8991	0.0965
OC	ALL	40	0.9259	0.0374
	X	10	0.9495	0.0453
	T	10	0.9086	0.0376
	P	10	0.9180	0.0320
	M	10	0.9274	0.0234
OO	ALL	36	0.9202	0.0396
	X	9	0.9384	0.0618
	T	9	0.9063	0.0306
	P	9	0.9133	0.0298
	M	9	0.9228	0.0239
SA	ALL	40	0.8613	0.1463
	X	10	0.8904	0.1171
	T	10	0.8467	0.1361
	P	10	0.8505	0.1421
	M	10	0.8577	0.1974
SM	ALL	36	0.9140	0.0390
	X	9	0.9470	0.0456
	T	9	0.9008	0.0348
	P	9	0.9036	0.0251
	M	9	0.9047	0.0331
WR	ALL	16	0.8453	0.1635
	X	4	0.8878	0.1700
	T	4	0.8252	0.1893
	P	4	0.8337	0.1900
	M	4	0.8343	0.1720
ALL	X	42	0.9266	0.0863
	T	42	0.8838	0.0917
	P	42	0.8898	0.0929
	M	42	0.8961	0.1109

TABLE 4.2

95 Percent Confidence Intervals for Migration Index

ALC	Low	High
ALL	0.885	0.914
OC	0.914	0.938
OO	0.907	0.933
SA	0.838	0.884
SM	0.901	0.927
WR	0.759	0.932

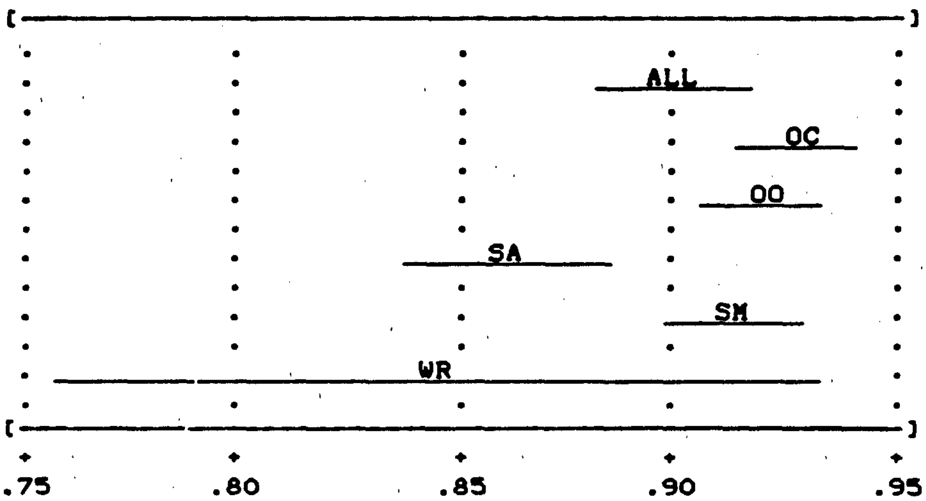

Figure 4.1 Graphic Intervals For Migration Index.

Table 4.1 also presents the mean index values by SMGC and Table 4.3 and Figure 4.2 presents the related 95 percent confidence intervals. These indicate that there is no statistical difference in the migration index between the categories. That is, the probability that an item will remain in the same category is about the same for each SMGC (although it is slightly higher for SMGC X). However, it will be shown later that the average length of time an item spends in a given category before migrating does differ

significantly.

TABLE 4.3

95 Percent Confidence Intervals for Migration Index
(By SMGC)

ALC	Low	High
ALL	0.885	0.914
X	0.901	0.953
T	0.856	0.912
P	0.862	0.918
M	0.863	0.930

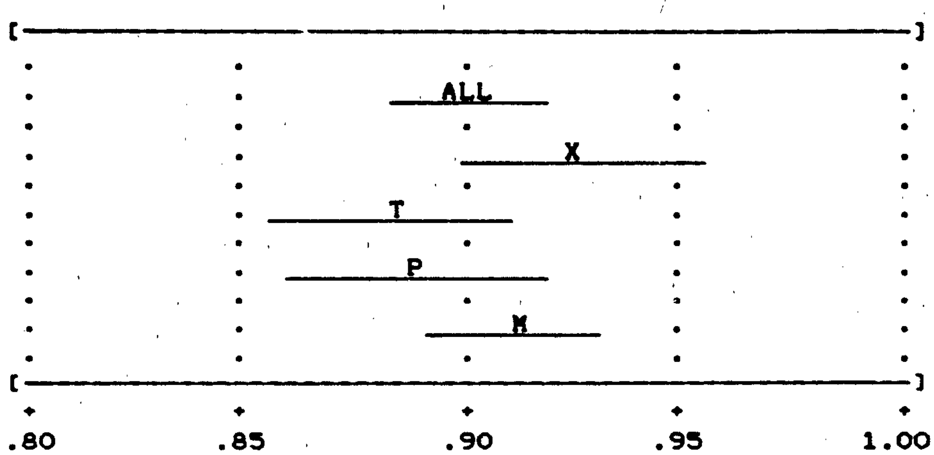

Figure 4.2 Graphic Intervals For Migration Index.

It is important to reiterate that the migration index values presented above are quarterly indexes; annual indexes would show a smaller percentage of items remaining in the same category. A one year match was made to estimate the annual index value. The grand mean for the year was 0.7868, 0.11 less than the quarterly index value. This means that in a years time, only about 79 percent of the items are in

the same category that they were in the year before and that about 21 percent have migrated. This does not count the migration of those items which migrated and then returned before the year was done, but just those in a different category at years end.

Time-Dependent Migration Analysis

An analysis was also made on the time-dependent aspects of migration. As described in Chapter 3, twelve consecutive quarters of data from San Antonio ALC was used for this part of the study. The results are summarized in Table 4.4 (the entire computer report can be found in Appendix D).

TABLE 4.4

Summary of Time-Dependent Analysis
SA-ALC June 81 to March 84

Mean number of migrations per item: 1.362

Mean number of consecutive quarters (per item) in:

All Categories:	5.57
X :	7.46
T :	4.94
P :	4.82
M :	4.51

Number of items not migrating:	44,029	25.47%
Number of items which migrated:	128,809	74.53%

Number of items starting in P & M :	8,970
Number of items starting in X & T :	145,739
Number of X & T items migrating up :	15,337
Number migrating back down to stay :	343

The analysis shows that, on the average, every item migrated about one and a third times. Since 25 percent of the items did not migrate at all, those that did migrate migrated more than once (on the average). The next set of figures in Table 4.4 are even more interesting. These represent the average number of quarters that an item was in the same category before migrating. Over all, <u>each item only stayed an average of 5.57 quarters (out of twelve) in one category before moving to another</u>. Breaking this out by SMGC shows that once an item gets to X, it tends to remain there longer than in the other SMGCs (perhaps this is because of a large number of items marked for disposal but not yet removed from the system). It is interesting to note that the other three SMGCs (T, P, and M) have about the same number for this measure, 4.5 to 4.9.

Most invent[illegible] systems make the implicit assumption that once an item enters a given management category it remains there indefinitely (5:29, 7:SMITH1). As was just demonstrated, items do <u>not</u> always remain in the same category. This has two serious implications. First, policies which treat every item in a category the same regardless of the amount of time an item has been in the category may not behave as expected. Second, analysis done with "snapshot" data taken with the same disregard for the time that individual items have been in a category will also be subject to the wrong interpretation. This is exactly what happened in the 1976 GAO report on the low value category at what was

then the Defense Supply Agency (DSA), now DLA (10). Smith and [illegible]bert demonstrated how migration had caused the "excess" stock that the GAO report attributed to overbuying (7). With the amount of migration experienced in this study, <u>the same warning must be given to AFLC</u>.

The importance of this cannot be overstressed. Figure 4.3 presents another way of visualizing the magnitude of the migration experienced in the system. The numbers in the bottom of the "pot" (e.g., 500,035 for X) are the average number of items in that category for the one year period covered by the diagrams. The number to the upper left of the pot is the total number items which migrated in to the category over the course of the year and the number to the upper right is the total number which migrated out. The sum of these numbers is listed below the pot. In the three higher categories, the number of items which migrated approaches the average number of items in the category. Considering that this is for just a single year, the management categories are clearly not as static as they are assumed to be! Here, as before, SMGC X tends to be the more stable of the four SMGCs, for perhaps the same reasons already discussed. Even so, 131 thousand items is still quite a substantial number.

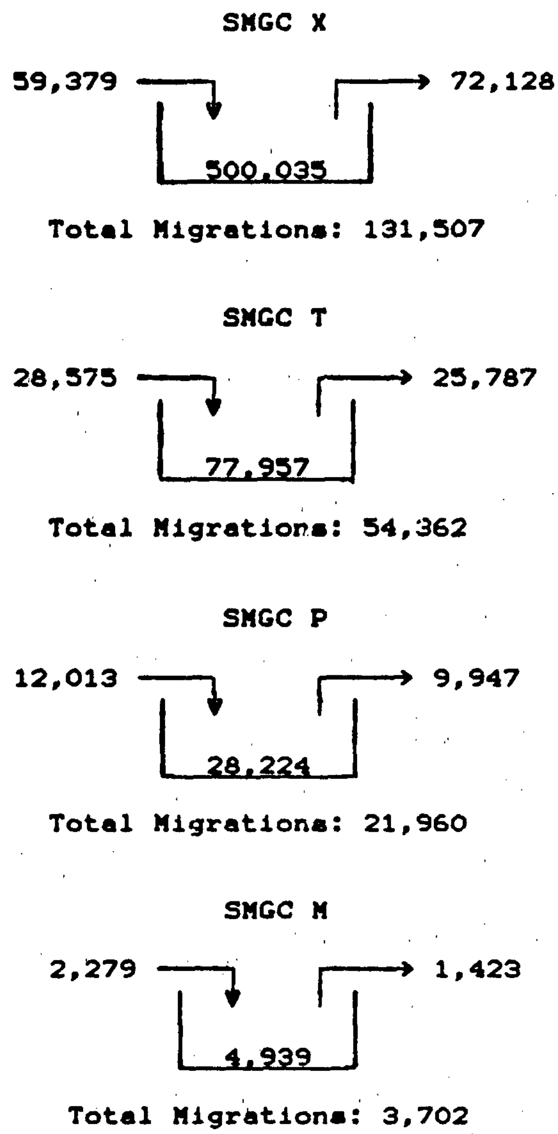

Figure 4.3 Total Annual Migration Flow Diagrams

Another problem that this much migration may cause is a larger than normal number of backorders, an excess of stock, or both. When an item migrates up because of a sharp increase in demands, it usually brings with it a large number of backorders since, by definition, it was not stocked to

handle the higher levels of demand which are now causing it to migrate. Similarly, when an item migrates down because of a sharp decrease in demands, it carries with it all of its unused stock which may be considered excessive once it reaches its new category. Both of these situations were observed at DESC by Smith and Gumbert in their study on migration (7:SMITH4-SMITH6). Therefore, it would be useful to know how much migration is occurring between the lower categories (X and T) and the upper two (P and M), especially the number of items migrating up and then back down again, since these items are subject to both backorder and excess stock problems.

An audit conducted at DESC reported that there was about $450 million of stock on hand to cover only $50 million in demand in the lowest management category, apparently the result of overbuying in that category. Because of this, DESC was required to dispose of the excess stock, or face severe budget cuts for that category. The study by Smith and Gumbert demonstrated that the excess stock was not acquired while the items were in the low category, but while they were in higher categories. Demand for the items had fallen about the time of the audit causing the items to migrate down, carrying there stock with them. Further analysis of the items in the low category revealed that the stock actually purchased in that category over a five year period only covered 97 percent of the demand for those items involved. Thus, it would have been impossible to overbuy in

that category. The excess stock was largely due to migration.

In the three years of San Antonio ALC data reviewed, only 10.5 percent of the items originally in the lower categories migrated to the higher categories, and of those, only 2.2 percent came back down to remain in the lower levels. At this point, it does not appear that this up-then-down migration is a problem at AFLC. However, this study did not consider the <u>value</u> of the items which did migrate this way nor did it look at any of the other ALCs. With the current one year minimum buy policy in effect, 343 items migrating from low to high to low again could indeed be very significant as a buy order was most likely issued on those items while they were in the higher categories. This last statement is based on the backorder analysis done by Smith and Gumbert in their migration study (6:SMITH5).

While the migration data collected during this study do not tend to support the contention that migration is causing the lower categories to go into long supply, a brief analysis of the Central Secondary Item Stratification (CSIS) report does. Table 4.5 summarizes the demand to on-hand ratio for the most recent CSIS report (CSIS). Note that there have only been only three SMGCs since November 1984, T, P, and M. The stock on hand data do not include WRM stockage requirements. This table indicates that the demands in SMGC T only account for eight percent of the stock

on hand, and that in SMGC M, the demands exceed stock on hand by fifteen percent. This is similar to the effects of migration found at DESC.

TABLE 4.5

AFLC Ratio of Demands to Stock on Hand

				Ratio
Overall:	Demands:	$2,035,848,404		
	On Hand:	$3,731,900,585	=	0.5455
SMGC T:	Demands:	$ 119,235,364		
	On Hand:	$1,497,673,823	=	0.0796
SMGC P:	Demand:	$ 606,815,524		
	On Hand:	$1,123,506,520	=	0.5401
SMGC M:	Demand:	$ 940,149,148		
	On Hand:	$ 816,396,373	=	1.1516

Given the amount of migration that occurs within the AFLC system, it is not surprising to find that the number of items originally in a each category steadily decreases each quarter. Table 4.6 lists by category the number of items in the first quarter remaining in each subsequent quarter. Unfortunately, a large transfer of assets to DLA was made during the sixth quarter (as shown in the figure) causing an unusually large drop in the number of items remaining that quarter. Even so, the information is still valuable.

The results presented in Table 4.6 are different from that found at DESC. There the rate of change in the number of original items in the category decreased each period with the greatest change in the first period. At AFLC, the rate of change is more erratic, sometimes increasing the next quarter, and sometimes decreasing. It is unclear what would account for such a dramatic difference, given that all of the other aspects of migration are similar. The reason may be because of policy changes in the AFLC system, or perhaps the DLA transfer, as an anomaly, may have affected the system beyond the quarter it actually occurred in. In any case, the point is that in just three years, a significant portion of the system had migrated out of the category in which it started. However, as mentioned before, this study only looked in detail at one ALC. It is important that the same analysis be performed for the other ALCs in order to have a full understanding of the impacts that migration is having there.

TABLE 4.6

Original Items Remaining Each Quarter
SA-ALC June 81 to March 84

SMGC X

Qtr	Number Remaining
1	125,238
2	121,664
3	119,717
4	117,901
5	110,643
6	73,061
7	67,155
8	66,480
9	66,234
10	65,344
11	58,589
12	39,846

SMGC T

Qtr	Number Remaining
1	20,501
2	19,360
3	17,652
4	16,263
5	14,680
6	7,695
7	6,492
8	5,649
9	5,611
10	4,978
11	4,323
12	2,795

SMGC P

Qtr	Number Remaining
1	7,667
2	7,173
3	6,556
4	6,096
5	5,652
6	2,792
7	2,440
8	2,213
9	2,184
10	2,029
11	1,842
12	1,197

SMGC M

Qtr	Number Remaining
1	1,303
2	1,242
3	1,175
4	1,145
5	1,097
6	315
7	291
8	281
9	272
10	261
11	242
12	191

Other Considerations

One of the characteristics of migration that an analyst might be interested in is the distribution of migration. Table 4.7 presents the migration frequency count table from the output of MIGSTATA. These data appear to have a Poisson distribution; a graphical comparison of these data and the theoretical Poisson with a mean of 1.36 supports this conclusion. However, a goodness of fit test fails to support the conclusion. This test results in an F^* of over 450, but the critical value is less than 20. The empirical distribution falls off in the tail much faster than does the theoretical one, though it fits well at the other end. Perhaps when the same analysis is performed on the other ALCs the combined result will be Poisson.

TABLE 4.7

Migration Frequency Count

MAX CELL COUNT = 59914
MIN CELL COUNT = 0
SUM ALL CELLS = 172838

NUMBER OF QUARTERS	COUNT
0	44029
1	59914
2	42447
3	17273
4	7220
5	1772
6	162
7	19
8	2
9	0
10	0
11	0

MEAN = 1.362478 STD DEV = 1.156144

The other frequency tables built in the study (see Appendix D) did not appear to fit any of the standard distributions; indeed, they were often somewhat erratic. None of the other statistics gathered lend themselves to this form of analysis.

Summary

This chapter has presented evidence to support the finding that a significant amount of migration is present within the AFLC inventory system. While further study of the problem must be made to determine the full impact of migration on current AFLC stockage policies, the inventory managers will now have some idea of the magnitude and basic characteristics of this problem.

V. Summary, Conclusions, and Recommendations

Summary and Conclusions

One of the basic unwritten assumptions in inventory management is that the items which make up a given management category remain in there indefinitely. However, work by Smith and Gumbert at DESC showed that the categories there are not static, but that there is a large number of items which migrate from one category to another. This study has demonstrated that a significant amount of migration is also present in the AFLC consumables inventory system.

Overall, the AFLC inventory system experiences about a ten percent migration per quarter. The annual migration rate could be as high as forty percent (although it typically will be much less than that). Each SMGC has about the same percentage of migrating items (although X and M are slightly more stable than T and P), but the ALCs do not. This may be because certain types of items are more prone to migration than others, though this was not addressed in the study.

An analysis was made of the time dependent aspects of migration. For this portion of the study, only a single ALC was investigated, the San Antonio ALC. The project data tapes for this ALC have the highest number of consecutive good quarters of data. It also appears to have the most

migration of the five ALCs, so the results should represent the worst case for the system.

The items in the SA-ALC data set as a whole migrated an average of 1.4 times in the three year period studied, even though twenty-five percent of the items did not migrate at all. On the whole, the items remained in the same category for an average 5.6 consecutive quarters in the twelve quarter stretch. Looking at this by SMGC, items in X remained there an average 7.5 quarters before migrating, while the each of the other categories had a figure of about 4.75 quarters. Considering that twenty-five percent of the items did not migrate at all, those that did migrate did not remain in the same category as long as indicated. This makes policy evaluation more complicated since many of the items which are normally included in such an evaluation may not have been under the policy's influence as they are assumed to have been and will thus provide misleading information.

An investigation was done to determine the number of items which migrated from the lower two categories (X and T) to the higher two (P and M) and the number of those which migrated back down to stay. Migration of this nature is particularly bad because the upward migration usually generates a greater number backorders than would be expected and the downward migration usually generates excess stock. This study revealed that about ten and a half percent of the items in the lower categories migrated up. This is consistent with the overall level of migration in the system.

However, only about two percent of those items migrated back down to stay. This does not seem to be a problem, but it does not consider the value of the migrating stock.

Another approach to the problem is to compare the total number of migrations to and from a category in a given period to the average number of items in the category over the same period. This was done with each of the SMGCs for a one year period. The results indicate that the number of migrations into and out of a category over a years time is about seventy-five percent of the average number of items in category (with the exception of X where the migrations represented only about twenty-six percent of the average population). Thus, while it appears that the categories are fairly stable in terms of the number of items that they contain, the mix of those items is <u>very</u> dynamic.

Another way of viewing the stability of the system is to determine how many of the items in a given category remain in the categroy each subsequent quarter. Using the same San Antonio data, the study counted the number of items remaining each quarter in each of the SMGCs. Unfortunately, a large number of items were transfered from AFLC to DLA halfway through the period being studied. Even so, it is clear that the number of original items steadily decreases each quarter. The impact here is that the effect of a policy change is usually evaluated using all of the items in the category in question, but many of those items may not

have been affected by the policy because they migrated in before it had its effect and many other items which may have been affected have migrated out. Thus, policy evaluation must be very careful to only analyse those items actually affected by the policy.

Recommendations

This study has provided a foundation in the understanding of the problem of item migration in the AFLC inventory system, but there is much more work to be done before any specific policy changes can be made. A similar analysis should be made of the repairables system (D041) to see if it is experiencing the same levels of migration as is the consumables inventory system. A shortcomming of this study of more immediate concern is that it did not determine the value of the stock on hand of the migrating items. This information is needed to determine the full impact of migration on the system.

A study should be conducted to examine why there is a significant difference in the level of migration between the five ALCs. This is could be caused by the mix of items managed by each ALC, but there is no evidence to support this conclusion. The study should determine the amount of migration for each stock class and then group them by similar levels of migration. Those classes which tend not to migrate should also be identified.

Current methods of policy evaluation are inadequate given the amount of migration present in the system. This is because the current policies assume thet an item remains in a category indefinately. New methods which discount the effects of migration must be developed. An inventory simulation model which includes migration should be developed for this purpose.

APPENDIX A

DATA FILE FORMATS

This appendix contains the data file formats of the tapes used in this study. The first format description is for those tapes labeled "IMDETQxx", "IMBAKQxx", or "SORTEDxx" where "xx" is replaced by the number of the project quarter the data are for. The second format description is for the tapes labeled "MIGDATA1" and "MDBAK1". The two tables that follow each describe one logical record in the data file. Each line in the table lists the name of a data element, identifies it as an integer (N), alpha (A), alpha-numeric (AN), or floating point (SN), gives its position in the record by character fields, and its length in characters. In the second table, the fields labeled "Migration Record for Qtr xx" are actually sub-records in that each contains the migration data for the specified quarter.

Master Tape Format

DATA NAME	USAGE	POSITION	LENGTH
I&S Stock Number	AN	1-15	15
Material Management	A	1-2	2
Federal Supply Classification	N	3-6	4
National Item ID Number	AN	7-15	9
Air Logistics Center	A	16-16	1
Quarter	N	17-18	2
Unit Price Standard	SN	19-27	9
Supply Management Grouping Code	AN	28-28	1
Management Intensity Code	AN	29-29	1
Special Code	A	30-30	1
Entry Date (into system)	N	31-35	5
Assets (summary)	SN	36-43	8
Assets Due-In	SN	44-50	7
Admin Lead Time (Days)	SN	51-52	2
Production Lead Time (Days)	SN	53-54	2
Program Monthly Demand Rate	SN	55-63	9

Migration Tape Format

DATA NAME	USAGE	POSITION	LENGTH
I&S Stock Number	AN	1-13	13
Federal Supply Classification	N	1-4	4
National Item ID Number	AN	5-13	9
Migration Record for Qtr 4	AN	14-32	19
Migration Record for Qtr 5	AN	33-51	19
Migration Record for Qtr 6	AN	52-70	19
Migration Record for Qtr 7	AN	71-89	19
Migration Record for Qtr 8	AN	90-108	19
Migration Record for Qtr 9	AN	109-127	19
Migration Record for Qtr 10	AN	128-146	19
Migration Record for Qtr 11	AN	147-165	19
Migration Record for Qtr 12	AN	166-184	19
Migration Record for Qtr 13	AN	185-203	19
Migration Record for Qtr 14	AN	204-222	19
Migration Record for Qtr 15	AN	223-241	19

where each Migration Record is:

SMCC	A	1-1	1
Unit Price (F9.2)	N	2-10	9
PMDR (F9.2)	N	11-19	9

Position here is the relative offset position in the record.

APPENDIX B

Computer Program and Job Control Language (JCL)

Source Listings

Over the course of this study, numerous program and Job Control Language (JCL) files were developed to run on AFLC's CREATE computer system. These programs were used to extract the needed data from the historical data tapes and to then analysis it. Because of the amount of data and the number of tapes to be worked with, seperate programs were written for each of the different tasks in the study (eg, data extraction, sorting, and analysing), and in many cases, the tasks were run for each quarter in the study. This resulted in a large number of similar files to keep track of.

In order to simplify the files management problem, a naming convention was developed for both disk files and data tapes. The programs associated with creating the project master tapes are called "MKMASTxx" (for MaKe MASTer) where 'xx' is replaced by the number of the project quarter that the program is for. After the project tapes were created, it turned out that they then had to be sorted. The JCL files which set up and runs the system sort routine is called "SORTxx", 'xx' being the number of the quarter being sorted. The program which matches the project tapes to collect migration statistics is called MATCHER, and the JCL files which match specific quarters are called "MATCHxx", where

'xx' is replaced by the number of the first quarter of the pair being matched (an exception to this wuld be MATCH48 which matched from quarter 4 to quarter 8). The files named "MATCHTxx" are used to match the tapes for the migration data tape.

The tapes generated during the study also had a naming convention. The AFLC EOQ Master tapes are labelled "EOQxxyzz" where 'xx' is the year of the tape, 'y' is the quarter of the year, and 'zz' is a two-letter code for the ALC that the data is for. The project data tapes are labelled "IMDETQxx" (for Item Migration DETailed, Quarter xx) where 'xx' is the quarter number and the back-up copy for each of these tapes is called "IMBAKQxx". The sorted files are stored on the tapes labelled "SORTEDxx". Finally, the Migration data tapes are called "MIGDATA1", "MIGDATA2", and "MIGBAK1".

The job control language for CREATE is called GCOS. It is a batch processing operating system which can use disk files (set up to look like a card deck) for input. The entire task to be done is refered to as a "job", and within the job there may be one or more "activities".

MKMSTO

MKMSTO is the program which reads specific data off of the EOQ Master tapes and writes it out to the project tape. This file creates the object code file MKMSTO.O which is used in the JCL file MKMAST (below).

This program is fairly straight forward. It reads a record off of the EOQ tape, extracts the required information, makes some adjustments to the data (to correct an oddly coded format and to sum the assets), then writes the data out to a new file. The records are processed and written out in the same order that they are found on the EOQ tapes, which means that they must later be sorted (the EOQ Master tapes are not completely sorted).

This program is set up to work with those EOQ Master tapes created before 1984, after which a slight change in the format was made. The program MKMSTN is to be used for the newer tapes. This program uses one input file and one output file.

```
##NORM,R(X1)
#:IDENT:
#:NOTE: AS OF 18 AUG 85
#:USERID:
#:LIMITS:5,35K,,15K
#:OPTION:FORTRAN,NOMAP
#:FORTY:NODECK,NOMAP,NFORM,NLNO
#:PRMFL:C*,W,S,PRED/MKMSTO.O
C** mkmsto **
      CALL FXOPT(32,1,1,0)
      CHARACTER MMC*2,NIIN*9,ALC*1,SMGC*1,MIC*1,SC*1,APR*1,
&                ADR*1,AALT*1,APLT*1,AA*330,BB*64
      INTEGER FSC,QARTER,IPR,IALT,IPLT,ASSETS,DEV,EDATE,
&              IOH,IAI,IDS,ICB,IIT,IMI,IUS,IDI,IDR,COUNT
      REAL UPRICE,PMDR
C** Initialize variables **
      COUNT  = 0
      REWIND 11
C** Read from old tape **
  1   READ(11,END=99)AA
      DECODE(AA,101)MMC,FSC,NIIN,IPR,APR,ALC,SMGC,MIC,
&             SC,EDATE,IOH,IAI,IDS,ICB,IIT,IMI,IUS,IDI,
&             IDR,ADR,IALT,AALT,IPLT,APLT
 101  FORMAT(17X,A2,I4,A9,21X,I8,A1,33X,A1,1X,2A1,
&             6X,A1,26X,I5,29X,8I7,43X,
&             I8,A1,45X,I2,A1,I3,A1)
C** Clean up certain items **
      COUNT  = COUNT + 1
      UPRICE = UNCODE(IPR,APR,2)
      PMDR   = UNCODE(IDR,ADR,2)
      IALT   = IFIX(UNCODE(IALT,AALT,0))
      IPLT   = IFIX(UNCODE(IPLT,APLT,0))
      ASSETS = IOH + IAI + IDS + ICB + IIT + IMI + IUS + IDI
C** Write to new tape **
      ENCODE(BB,110)MMC,FSC,NIIN,ALC,QARTER,UPRICE,SMGC,MIC,
&                   SC,EDATE,ASSETS,IDI,IALT,IPLT,PMDR
 110  FORMAT(A2,I4,A9,A1,I2,F9.2,3A1,I5,I8,I7,I2,I3,F9.2)
      WRITE(10)BB
      GOTO 1
C** Done with tape **
  99  WRITE(19,202)COUNT
 202  FORMAT(' Read ',I6,' records.')
      STOP
      END
C****
      REAL FUNCTION  UNCODE(INT1,ALF,P)
      INTEGER INT1,INT2,P,I
      CHARACTER*1 ALF,CODE(9)
C**   INT is the integer portion of the number,
C**   alf is the alpha portion, and P is the number of
C**   decimals in the real number.
      DATA CODE/'A','B','C','D','E','F','G','H','I'/
```

```
      DO 10 I = 1,9
         IF (ALF.EQ.CODE(I)) GOTO 20
   10 CONTINUE
C**   No match, so restore as is
      DECODE(ALF,101)INT2
  101 FORMAT(I1)
      UNCODE = FLOAT((INT1*10) + INT2)/(10.**P)
      GOTO 89
   20 UNCODE = FLOAT((INT1*10) + I)/(10.**P)
   89 RETURN
      END
*:ENDJOB
```

MKMAST

MKMAST (for MaKe project MASTer tape) is the JCL file which sets up the tapes and files for MKMSTO. This file sets up the ALCs to run one at time in sequence in order to minimize the number of tape drives and file space required.

The program first copies the entire EOQ file for the ALC being processed onto a temporary disk file and (except for the first activity) copies the new file from the previous ALC processed onto the project tape. Then the program which actually will transfer the data is invoked. The last activity copies the last disk file to the project tape and creates a back-up of the tape. Only two tape drives are required for this job.

```
100##NORM,R(X1)
110#:IDENT:
120#:USERID:
130#:LIMITS:500,35K,,15K
140#:NOTE:          THIS DECK IS FOR QUARTER Q03
150#:NOTE:    THE FOLLOWING PART IS FOR ALC OC
160#:NOTE:          SET UP DATA FILES
170#:UTILITY
180#:LIMITS:500
190#:TAPE9:IN,X1D,,PAH64,,EOQ811OC,,DEN16
200#:MSG2:USE PAH65 AS REEL 2 FOR EOQ811OC
210#:FILE:OT,A1S
220#:FUTIL:IN,OT,COPY/1F/
230#:NOTE:           EXTRACT PROJECT DATA
240#:OPTION:FORTRAN,NOMAP
250#:SELECT:PRED/MKMSTO.O
260#:EXECUTE
270#:LIMITS:500,35K,,10K
280#:REMOTE:19
290#:FILE:10,P1S
300#:FILE:11,A1R
310#:NOTE:    THE FOLLOWING PART IS FOR ALC OO
320#:NOTE:          SET UP DATA FILES
330#:UTILITY
340#:LIMITS:500
350#:TAPE9:IN,X2D,,PAH72,,EOQ811OO,,DEN16
360#:MSG2:USE PAH73 AS REEL 2 FOR EOQ811OO
370#:FILE:OT,A2S
380#:FUTIL:IN,OT,COPY/1F/
390#:TAPE9:TO,T2D,,92163,,IMDETQ03/R,,DEN62
400#:FILE:FO,P1R
410#:FUTIL:FO,TO,RWD/FO,TO/,COPY/1F/
420#:NOTE:           EXTRACT PROJECT DATA
430#:OPTION:FORTRAN,NOMAP
440#:SELECT:PRED/MKMSTO.O
450#:EXECUTE
460#:LIMITS:500,35K,,10K
470#:REMOTE:19
480#:FILE:10,P2S
490#:FILE:11,A2R
500#:NOTE:    THE FOLLOWING PART IS FOR ALC SA
510#:NOTE:          SET UP DATA FILES
520#:UTILITY
530#:LIMITS:500
540#:TAPE9:IN,X3D,,PAH80,,EOQ811SA,,DEN16
550#:MSG2:USE PAH81,PAH82 AS REEL 2,3 FOR EOQ811SA
560#:FILE:OT,A3S
570#:FUTIL:IN,OT,COPY/1F/
580#:TAPE9:TO,T3D,,92163,,IMDETQ03/R,,DEN62
590#:FILE:FO,P2R
600#:FUTIL:FO,TO,RWD/FO,TO/,SKIP/,1F/,COPY/1F/
```

```
610$:NOTE:              EXTRACT PROJECT DATA
620$:OPTION:FORTRAN,NOMAP
630$:SELECT:PRED/MKMSTO.O
640$:EXECUTE
650$:LIMITS:500,35K,,10K
660$:REMOTE:19
670$:FILE:10,P3S
680$:FILE:11,A3R
690$:NOTE:    THE FOLLOWING PART IS FOR ALC SM
700$:NOTE:              SET UP DATA FILES
710$:UTILITY
720$:LIMITS:500
730$:TAPE9:IN,X4D,,PAH92,,EOQ811SM,,DEN16
740$:MSG2:USE PAH93 AS REEL 2 FOR EOQ811SM
750$:FILE:OT,A4S
760$:FUTIL:IN,OT,COPY/1F/
770$:TAPE9:TO,T4D,,92163,,IMDETQ03/R,,DEN62
780$:FILE:FO,P3R
790$:FUTIL:FO,TO,RWD/FO,TO/,SKIP/,2F/,COPY/1F/
800$:NOTE:              EXTRACT PROJECT DATA
810$:OPTION:FORTRAN,NOMAP
820$:SELECT:PRED/MKMSTO.O
830$:EXECUTE
840$:LIMITS:500,35K,,10K
850$:REMOTE:19
860$:FILE:10,P4S
870$:FILE:11,A4R
880$:NOTE:    THE FOLLOWING PART IS FOR ALC WR
890$:NOTE:              SET UP DATA FILES
900$:UTILITY
910$:LIMITS:500
920$:TAPE9:IN,X5D,,PAI00,,EOQ811WR,,DEN16
930$:MSG2:USE PAI01,PAI02 AS REEL 2,3 FOR EOQ811WR
940$:FILE:OT,A5S
950$:FUTIL:IN,OT,COPY/1F/
960$:TAPE9:TO,T5D,,92163,,IMDETQ03/R,,DEN62
970$:FILE:FO,P4R
980$:FUTIL:FO,TO,RWD/FO,TO/,SKIP/,3F/,COPY/1F/
990$:NOTE:              EXTRACT PROJECT DATA
1000$:OPTION:FORTRAN,NOMAP
1010$:SELECT:PRED/MKMSTO.O
1020$:EXECUTE
1030$:LIMITS:500,35K,,10K
1040$:REMOTE:19
1050$:FILE:10,P5S
1060$:FILE:11,A5R
1070$:NOTE:     CLEAN UP FILES AND MAKE BACK-UP
1080$:UTILITY
1090$:LIMITS:500
1100$:TAPE9:OT,M1D,,92163,,IMDETQ03/R,,DEN62
1110$:TAPE9:BU,M2D,,92292,,IMBAKQ03/R,,DEN62
1120$:FILE:IS,P5R
1130$:FUTIL:IS,OT,RWD/IS,OT/,SKIP/,4F/,COPY/1F/
```

```
1140#:FUTIL:OT,BU,RWD/OT,BU/,MCOPY/4F/,COPY/1F/
1150#:FUTIL:BU,OT,RWD/BU,OT/,COPY/1F/
1160#:ENDJOB
```

SORTMAST

This next JCL file is used to sort the files created by MKMAST before they are used to collect the migration statistics. This was found to be necessary since most of the EOQ history tapes were not completely sorted. This job works on a single ALC at a time and uses the sorting utility available on the system. The job is structured to copy each file to disk, sort them, then copy them back to the new tape. The original project tape is left intacted in case it is needed again in its original form. This job only uses a single tape drive at a time.

```
10##NORM,R(X1)
20#:IDENT:
30#:LIMITS:60,40K,,15K
40#:UTILITY
50#:LIMITS:60
60#:TAPE9:IN,T1D,,99999,,IXDETQXX,,DEN62
70#:FILE:01,A1S
80#:FILE:02,A2S
90#:FILE:03,A3S
100#:FILE:04,A4S
110#:FILE:05,A5S
120#:FUTIL:IN,01,RWD/IN,01/,COPY/1F/,RWD/IN,01/
130#:FUTIL:IN,02,SKIP/1F,/,COPY/1F/,RWD/IN,02/
140#:FUTIL:IN,03,SKIP/2F,/,COPY/1F/,RWD/IN,03/
150#:FUTIL:IN,04,SKIP/3F,/,COPY/1F/,RWD/IN,04/
160#:FUTIL:IN,05,SKIP/4F,/,COPY/1F/,RWD/IN,05/
165#:NOTE:   SORT FILE 1
170#:LOWLOAD
180#:GMAP:NDECK,ON5,SYMTAB
190#:LIMITS:60,,,2K
200:600SM
210:SORT:FCB,,11
220:FIELD:(C2,C13,C15,C5)
230:SEQ:(A2,A4)
240:FILCB:FCB,**,2
250:END
260#:EXECUTE
270#:LIMITS:60,40K,,15K
280#:FILE:SA,A1R
290#:FILE:S2,B1S
300#:FILE:S1,F1R,1000R
310#:FILE:S2,F2R,1000R
320#:FILE:S3,F3R,1000R
325#:NOTE:    SORT FILE  2
330#:LOWLOAD
340#:GMAP:NDECK,ON5,SYMTAB
350#:LIMITS:60,,,2K
360:600SM
370:SORT:FCB,,11
380:FIELD:(C2,C13,C15,C5)
390:SEQ:(A2,A4)
400:FILCB:FCB,**,2
410:END
420#:EXECUTE
430#:LIMITS:60,40K,,15K
440#:FILE:SA,A2R
450#:FILE:S2,B2S
460#:FILE:S1,F1R,1000R
470#:FILE:S2,F2R,1000R
480#:FILE:S3,F3R,1000R
485#:NOTE:     SORT FILE 3
490#:LOWLOAD
500#:GMAP:NDECK,ON5,SYMTAB
```

```
510#:LIMITS:60,,,2K
520:600SM
530:SORT:FCB,,11
540:FIELD:(C2,C13,C15,C5)
550:SEQ:(A2,A4)
560:FILCB:FCB,**,2
570:END
580#:EXECUTE
590#:LIMITS:60,40K,,15K
600#:FILE:SA,A3R
610#:FILE:SZ,B3S
620#:FILE:S1,F1R,1000R
630#:FILE:S2,F2R,1000R
640#:FILE:S3,F3R,1000R
645#:NOTE:    SORT FILE 4
650#:LOWLOAD
660#:GMAP:NDECK,ON5,SYMTAB
670#:LIMITS:60,,,2K
680:600SM
690:SORT:FCB,,11
700:FIELD:(C2,C13,C15,C5)
710:SEQ:(A2,A4)
720:FILCB:FCB,**,2
730:END
740#:EXECUTE
750#:LIMITS:60,40K,,15K
760#:FILE:SA,A4R
770#:FILE:SZ,B4S
780#:FILE:S1,F1R,1000R
790#:FILE:S2,F2R,1000R
800#:FILE:S3,F3R,1000R
805#:NOTE:    SORT FILE 5
810#:LOWLOAD
820#:GMAP:NDECK,ON5,SYMTAB
830#:LIMITS:60,,,2K
840:600SM
850:SORT:FCB,,11
860:FIELD:(C2,C13,C15,C5)
870:SEQ:(A2,A4)
880:FILCB:FCB,**,2
890:END
900#:EXECUTE
910#:LIMITS:60,40K,,15K
920#:FILE:SA,A5R
930#:FILE:SZ,B5S
940#:FILE:S1,F1R,1000R
950#:FILE:S2,F2R,1000R
960#:FILE:S3,F3R,1000R
970#:UTILITY
980#:LIMITS:60
990#:TAPE9:OT,T2D,,99999,,SORTEDZZ/R,,DEN62
1000#:FILE:I1,B1R
1010#:FILE:I2,B2R
```

```
1020#:FILE:I3,B3R
1030#:FILE:I4,B4R
1040#:FILE:I5,B5R
1050#:FUTIL:I1,OT,RWD/I1,OT/,COPY/1F/
1060#:FUTIL:I2,OT,RWD/I2,OT/,SKIP/,1F/,COPY/1F/
1070#:FUTIL:I3,OT,RWD/I3,OT/,SKIP/,2F/,COPY/1F/
1080#:FUTIL:I4,OT,RWD/I4,OT/,SKIP/,3F/,COPY/1F/
1090#:FUTIL:I5,OT,RWD/I5,OT/,SKIP/,4F/,COPY/1F/
1100#:ENDJOB
```

MATCHER

MATCHER is the program that compares two data files and reports on the amount of migration that occured during the time between them. When this program is run, it leaves an object code file on disk to be used in the JCL file which follows after it.

The program sets up the variables, then reads one record from each file, keeping track of the number of records read from each, and counting the number of items in each SMGC. The federal stock codes (FSC) of the two items are then compared. If they are the same, then the national item ID numbers (NIIN) are compared. If they still match, then the SMGCs are used to increment the counter which keeps track of migrations in the system (the array MIGRATE).

If either the FSC or the NIIN from file A is larger then that from file B, this indicates that the item from file B is new, so a count to that effect is made and the program reads another record from file B (in order to get "caught up" with file A). If the FSC or NIIN from file B is the larger, then this indicates that the item from file A has left the system. Again a count is made and the program reads another record from file A. If when either file is completed, the other is read until it is done, then the program report is written. No new files are created by this program.

```
##NORM,R(X1)
#:IDENT:
#:NOTE: AS OF 19 SEPT
#:USERID:
#:LIMITS:15,35K,,15K
#:OPTION:FORTRAN,NOMAP
#:FORTY:DECK,NOMAP
#:PRMFL:C*,W,S,PRED/MATCH.O
C**  MATCHER  **
      CALL FXOPT(32,1,1,0)
      DIMENSION CLABEL(5)
      CHARACTER AMMC*2,ANIIN*9,AALC*1,ASMGC*1,AMIC*1,ASC*1,
&               AA*64,BMMC*2,BNIIN*9.BALC*1,BSMGC*1,BMIC*1,
&               BSC*1,BB*64,CLABEL*1
      INTEGER AFSC,AQRTER,AALT,APLT,AASSET,AEDATE,AIDI,
&      ACOUNT,BFSC,BQRTER,BALT,BPLT,BASSET,BEDATE,BIDI,
&      BCOUNT,MIGRATE(5,5),ACNT(4),BCNT(4),MATCH,COUNT,
&      IN,OUT
      REAL APRICE,APMDR,BPRICE,BPMDR,MINDEX(5)
C
C** INITIALIZE VARIABLES **
      DATA MIGRATE,ACNT,BCNT/33*0/
      DATA CLABEL/'X','T','P','M','I'/
      COUNT  = 0
      ACOUNT = 0
      BCOUNT = 0
      MATCH  = 1
      OUT = 5
      IN  = 5
C
C**  READ FROM FILE A  **
   1  READ(11,END=98)AA
      DECODE(AA,110)AMMC,AFSC,ANIIN,AALC,AQRTER,APRICE,
&         ASMGC,AMIC,ASC,AEDATE,AASSET,AIDI,AALT,APLT,APMDR
      ACOUNT = ACOUNT + 1
      ACNT(INDEX(ASMGC)) = ACNT(INDEX(ASMGC)) + 1
      IF (MATCH.EQ.O) GOTO 3
C
C**  READ FROM FILE B  **
   2  READ(12,END=99)BB
      DECODE(BB,110)BMMC,BFSC,BNIIN,BALC,BQRTER,BPRICE,
&         BSMGC,BMIC,BSC,BEDATE,BASSET,BIDI,BALT,BPLT,BPMDR
      BCOUNT = BCOUNT + 1
      BCNT(INDEX(BSMGC)) = BCNT(INDEX(BSMGC)) + 1
 110  FORMAT(A2,I4,A9,A1,I2,F9.2,3A1,I5,I8,I7,I2,I3,F9.2)
C
C**  CHECK FOR MATCHING ITEMS  **
   3  COUNT = COUNT + 1
      IF (AFSC - BFSC) 5,4,6
   4  IF (ANIIN.EQ.BNIIN) GOTO 7
      IF (ANIIN.GT.BNIIN) GOTO 6
   5  MIGRATE(INDEX(ASMGC),OUT)=MIGRATE(INDEX(ASMGC),OUT)+1
      MATCH = 0
```

```
      GOTO 1
    6 MIGRATE(IN,INDEX(BSMGC)) = MIGRATE(IN,INDEX(BSMGC))+1
      MATCH = 0
      GOTO 2
    7 MIGRATE(INDEX(ASMGC),INDEX(BSMGC)) =
     &   MIGRATE(INDEX(ASMGC),INDEX(BSMGC)) + 1
    8 MATCH = 1
      GOTO 1
C
C** DONE WITH TAPE A **
   98 IF (BFSC.EQ.9999) GOTO 999
      AFSC = 9999
      GOTO 3
C
C** DONE WITH TAPE B **
   99 IF (AFSC.EQ.9999) GOTO 999
      BFSC = 9999
      GOTO 3
C
C** GENERATE JOB REPORT  **
  999 DO 980 I = 1,4
  980    MINDEX(I) = MIGRATE(I,I)/AMINO(ACNT(I),BCNT(I))
      MINDEX(5) = (MINDEX(1)+MINDEX(2)+MINDEX(3)+MINDEX(4))
     &     /4.0
      WRITE(10,900)
      WRITE(10,901)ACOUNT,BCOUNT,COUNT
      WRITE(10,912)(COUNT-AMAXO(ACOUNT,BCOUNT))/
     &     AMINO(ACOUNT,BCOUNT)
      WRITE(10,911)(ACNT(I),I=1,4),(BCNT(I),I=1,4)
      WRITE(10,902)
      WRITE(10,903)(CLABEL(I),(MIGRATE(I,J),J=1,5),I=1,5)
      WRITE(10,904)(MINDEX(I),I=1,5)
  900 FORMAT('0****  MIGRATION REPORT  ****')
  901 FORMAT('0NUMBER OF RECORDS PROCESSED FROM FILE A = ',
     &        I7,/,
     &       ' NUMBER OF RECORDS PROCESSED FROM FILE B = ',
     &        I7,/,
     &       ' TOTAL NUMBER OF ITEMS = ',I7)
  912 FORMAT(' MISMATCH INDEX       = ',F9.5,//)
  911 FORMAT(' BY SMGC IN A: ',4(I7,1X),/,
     &       ' BY SMGC IN B: ',4(I7,1X),//)
  902 FORMAT('0FROM\TO    X      T      P      M      O')
  903 FORMAT(5(2X,A1,5X,I6,1X,I6,1X,I6,1X,I6,1X,I6,/))
  904 FORMAT(' MIGRATION INDEX BY SMGC (AND AVG): ',
     &        5(F9.5,1X))
      STOP
      END
```

```
C
C****  INDEX  ****
      INTEGER FUNCTION INDEX(SMGC)
      CHARACTER SMGC*1
      IF (SMGC.EQ.'X') INDEX = 1
      IF (SMGC.EQ.'T') INDEX = 2
      IF (SMGC.EQ.'P') INDEX = 3
      IF (SMGC.EQ.'M') INDEX = 4
      RETURN
      END
*:ENDJOB
```

MATCHO

MATCHO is a template JCL file which sets up the files for the program MATCHER above. To use, the analyst replaces the tape IDs in lines 70 and 80 with the actual labels to be used. If not all five ALCs are to be processed (eg, if the data for one of them is bad or missing), then the lines for the unused parts of the file should be deleted (taking care to notice the logical unit designators (LUDs) in the file).

The JCL assumes that the data for each ALC for a given quarter is in a seperate file on the same tape. It first writes out each tape file to a temporary disk file with one of the system utilities and releases the tape units. The data in the files will be used in the same order that they were in on the original tape and are released when no longer needed. No new files are created (except for the records written to the system remote output file). Only two tape drives are required (both for input tapes) and these are released after the first activity in the job.

```
10##NORM,R(X1)
20#:IDENT:
30#:USERID:
40#:LIMITS:200,35K,,10K
50#:UTILITY
60#:LIMITS:200
70#:TAPE9:IN,T1D,,88888,,SORTEDXX,,DEN62
80#:TAPE9:I2,T2D,,99999,,SORTEDZZ,,DEN62
90#:FILE:A1,A1S
100#:FILE:A2,A2S
110#:FILE:A3,A3S
120#:FILE:A4,A4S
130#:FILE:A5,A5S
140#:FILE:B1,B1S
150#:FILE:B2,B2S
160#:FILE:B3,B3S
170#:FILE:B4,B4S
180#:FILE:B5,B5S
190#:FUTIL:IN,A1,RWD/IN,A1/,COPY/1F/,RWD/IN,A1/
200#:FUTIL:IN,A2,SKIP/1F,/,COPY/1F/,RWD/IN,A2/
210#:FUTIL:IN,A3,SKIP/2F,/,COPY/1F/,RWD/IN,A3/
220#:FUTIL:IN,A4,SKIP/3F,/,COPY/1F/,RWD/IN,A4/
230#:FUTIL:IN,A5,SKIP/4F,/,COPY/1F/,RWD/IN,A5/
240#:FUTIL:I2,B1,RWD/I2,B1/,COPY/1F/,RWD/I2,B1/
250#:FUTIL:I2,B2,SKIP/1F,/,COPY/1F/,RUD/I2,B2/
260#:FUTIL:I2,B3,SKIP/2F,/,COPY/1F/,RWD/I2,B3/
270#:FUTIL:I2,B4,SKIP/3F,/,COPY/1F/,RWD/I2,B4/
280#:FUTIL:I2,B5,SKIP/4F,/,COPY/1F/,RWD/I2,B5/
285#:NOTE:                  MATCH FILE 1
290#:OPTION:FORTRAN,NOMAP
300#:SELECT:PRED/MATCH.O
310#:EXECUTE
320#:LIMITS:200,35K,,10K
330#:REMOTE:10
340#:FILE:11,A1R
350#:FILE:12,B1R
355#:NOTE:                  MATCH FILE 2
360#:OPTION:FORTRAN,NOMAP
370#:SELECT:PRED/MATCH.O
380#:EXECUTE
390#:LIMITS:200,35K,,10K
400#:REMOTE:10
410#:FILE:11,A2R
420#:FILE:12,B2R
425#:NOTE:                  MATCH FILE 3
430#:OPTION:FORTRAN,NOMAP
440#:SELECT:PRED/MATCH.O
450#:EXECUTE
460#:LIMITS:200,35K,,10K
470#:REMOTE:10
480#:FILE:11,A3R
490#:FILE:12,B3R
```

```
495#:NOTE:                    MATCH FILE 4
500#:OPTION:FORTRAN,NOMAP
510#:SELECT:PRED/MATCH.O
520#:EXECUTE
530#:LIMITS:200,35K,,10K
540#:REMOTE:10
550#:FILE:11,A4R
560#:FILE:12,B4R
565#:NOTE:      MATCH FILE 5
570#:OPTION:FORTRAN,NOMAP
580#:SELECT:PRED/MATCH.O
590#:EXECUTE
600#:LIMITS:200,35K,,10K
610#:REMOTE:10
620#:FILE:11,A5R
630#:FILE:12,B5R
640#:ENDJOB
```

MATCHTP

MATCHTP is the template file for the jobs which are used to create the time-dependent data file on MIGDATA1. The matching logic is the same as in MATCHER, except that instead of simply counting the matches, records are written out to a new file. The quarter to be added is designated file A, and the existing migdata file is file B.

```
##NORM,R(X1)
#:IDENT:
#:LIMITS:75,35K,,10K
#:UTILITY
#:LIMITS:75
#:TAPE9:I1,T1D,,9XXXX,,SORTEDQQ,,DEN62
#:TAPE9:I2,T2D,,92160,,MIGDATA1,,DEN62
#:FILE:01,Q1S
#:FILE:02,M1S
#:FUTIL:I1,01,SKIP/2F/,COPY/1F/,RWD/I1,01/
#:FUTIL:I2,02,RWD/I2,02/,COPY/1F/,RWD/I2,02/
#:OPTION:FORTRAN,NOMAP
#:FORTY:NODECK,NOMAP
C**  MATCHTP  **
      CALL FXOPT(32,1,1,0)
      DIMENSION MIGREC(12)
      CHARACTER AMMC*2,ANIIN*9,AALC*1,ASMGC*1,AMIC*1,ASC*1,
&               AA*64,BNIIN*9,BSMGC*1,MIGREC*19,ZZZ*19
      INTEGER AFSC,AQRTER,AALT,APLT,AASSET,AEDATE,AIDI,
&             BFSC,BQRTER,MATCH
      REAL APRICE,APMDR,BPRICE,BPMDR
C** INITIALIZE VARIABLES **
      DATA MIGREC,ZZZ/13*'ZZZZZZZZZZZZZZZZZZZ'/
      MATCH  = 1
      QTR = QQ-3
C**  READ FROM QTR DATA FILE  **
   1  READ(10,END=98)AA
      DECODE(AA,110)AMMC,AFSC,ANIIN,AALC,AQRTER,APRICE,
&         ASMGC,AMIC,ASC,AEDATE,AASSET,AIDI,AALT,APLT,APMDR
 110  FORMAT(A2,I4,A9,A1,I2,F9.2,3A1,I5,I8,I7,I2,I3,F9.2)
      IF (MATCH.EQ.0) GOTO 3
C**  READ FROM MIGDATA FILE  **
   2  READ(11,END=99)BFSC,BNIIN,(MIGREC(I),I=1,12)
C**  CHECK FOR MATCHING ITEMS  **
   3  IF (AFSC - BFSC) 5,4,6
   4  IF (ANIIN.EQ.BNIIN) GOTO 7
      IF (ANIIN.GT.BNIIN) GOTO 6
C**  NEW ITEM - BUILD NEW RECORD  **
   5  DO 51 I=1,12
  51    MIGREC(I) = ZZZ
      ENCODE(MIGREC(QTR),130)ASMGC,APRICE,APMDR
      WRITE(12)AFSC,ANIIN,(MIGREC(I),I=1,12)
      MATCH = 0
      GOTO 1
C**  ITEM LEFT  **
   6  MIGREC(QTR) = ZZZ
      WRITE(12)BFSC,BNIIN,(MIGREC(I),I=1,12)
      MATCH = 0
      GOTO 2
C**  ITEMS MATCH - FILL IN RECORD  **
   7  ENCODE(MIGREC(QTR),130)ASMGC,APRICE,APMDR
      WRITE(12)AFSC,ANIIN,(MIGREC(I),I=1,12)
      MATCH = 1
```

```
      GOTO 1
 130  FORMAT(A1,2F9.2)
C**  DONE WITH QTR TAPE  **
  98  IF (BFSC.EQ.9999) GOTO 999
      AFSC = 9999
      GOTO 3
C**  DONE WITH MIGDATA TAPE  **
  99  IF (AFSC.EQ.9999) GOTO 999
      BFSC = 9999
      GOTO 3
 999  STOP
      END
$:EXECUTE
$:LIMITS:75
$:FILE:10,Q1R
$:FILE:11,M1R
$:FILE:12,M2S
$:UTILITY
$:LIMITS:75
$:FILE:IN,M2R
$:TAPE9:OT,T3D,,92160,,MIGDATA1/R,,DEN62
$:TAPE9:O2,T4D,,92275,,MDBAK1/R,,DEN62
$:FUTIL:IN,OT,RWD/IN,OT/,COPY/1F/
$:FUTIL:IN,O2,RWD/IN,O2/,COPY/1F/
$:ENDJOB
```

MIGSTATA

MIGSTATA is the program which analysis the time-dependent migration data on the MIGDATA1 tape. The program operates on one item at a time. It keeps two types of statistics, one type for the item being processed at the time, and the other for the data as a whole. The item statistics are summarize and stored in the system statistics.

After the item is read into the buffer, it is checked to see if it is to be filtered out (if it is in the system for three quarters or less), or if drops out of the system for a single quarter, but is in the system otherwise. These measures are there to minimize some problems found in the data. After this, counts are made to the number of times the item migrates, and enters or leaves the system. Items with high migration counts, and items which move in and out of the system are written out to special files for later review. System statistics are updated, and then the report is written. This job only requires a single tape drive at any one time, since the migration date file is copied to before the analysis begins.

```
##NORM,R(X1)
$:IDENT:
$:LIMITS:400,35K,,10K
$:UTILITY
$:LIMITS:400
$:TAPE9:IN,T1D,,92160,,MIGDATA1,,DEN62
$:FILE:OT,Q1S
$:FUTIL:IN,OT,RWD/IN/,COPY/1F/,RWD/IN,OT/
$:OPTION:FORTRAN,NOMAP
$:FORTY:NODECK,NOMAP
C** MIGSTATS **
      CALL FXOPT(32,1,1,0)
      DIMENSION MIGREC(12),SMGC(12),PRICE(12),PMDR(12)
      CHARACTER NIIN*9,SMGC*1,MIGREC*20
      INTEGER FSC,MIGCNT,FREQCT(12),NUMQTR,ZCNT,NOZCNT,
&       NZCNT,MCNT,OIOCNT,IOICNT,NUMREC,MAXFRQ,MINFRQ,
&       DMPCNT,CATCNT,CURCAT,CATFRQ(6,12),CFCNT(6),MAXCF(6),
&       MINCF(6),FREQSM,CATSUM(6),MIGSUM,CHGCNT(2,6)
      REAL PRICE,PMDR,MCMEAN,MCVAR,NZMEAN,NZVAR,CFMEAN(6),
&          CFVAR(6),DMDCHG,DCWNM
C** INITIALIZE VARIABLES **
      DATA CATFRQ,CHGCNT/84*0/
      DATA CFMEAN,CFVAR,CFCNT,CATSUM/12*0.0,12*0/
      DATA MAXCF,MINCF/6*0,6*9999/
      DMPCNT = 0
      FREQSM = 0
      IOICNT = 0
      OIOCNT = 0
      MAXFRQ = 0
      MINFRQ = 9999
      MIGSUM = 0
      MCMEAN = 0.0
      MCVAR  = 0.0
      MCNT   = 0
      NUMQTR = 12
      NUMREC = 0
      NOZCNT = 0
      NZMEAN = 0.0
      NZVAR  = 0.0
      NZCNT  = 0
C**
C** READ FROM FILE **
   1  READ(10,END = 99)FSC,NIIN,(MIGREC(I),I=1,12)
      NUMREC = NUMREC + 1
      DO 10 I = 1,12
  10    DECODE(MIGREC(I),100)SMGC(I),PRICE(I),PMDR(I)
 100  FORMAT(A1,2F9.2)
C**
C** COMPUTE STATISTICS AND WRITE REPORT **
C**
C** COMPUTE MIGRATION FREQUENCY FOR THIS ITEM **
      IENTER = 0
      ILEFT  = 0
```

```
      ZCNT   = 0
      CATCNT = 1
      MIGCNT = 0
      CURCAT = INDEX(SMGC(1))
C**
C** COUNT # OF QTRS ITEM NOT IN SYSTEM
      DO 15 I = 1,NUMQTR
  15     IF (SMGC(I).EQ.'Z') ZCNT = ZCNT + 1
C**
C** IGNORE ITEMS NOT IN SYSTEM > 3 QTRS
      IF (ZCNT.LT.9) GOTO 16
         DMPCNT = DMPCNT + 1
         GOTO 1
C**
C** IF ONLY ONE CONSECUTIVE QUARTER IS MISSING,
C** FILL IN DATA WITH DATA FROM PREVIOUS QTR
  16  DO 17 I = 2,NUMQTR-1
         IF ((SMGC(I).NE.'Z').OR.
     &      (SMGC(I-1).EQ.'Z').OR.(SMGC(I+1).EQ.'Z'))GOTO 17
            SMGC(I)  = SMGC(I-1)
            PRICE(I) = PRICE(I-1)
            PMDR(I)  = PMDR(I-1)
  17  CONTINUE
C**
C** RE-DO ZCNT AFTER FILTERING
      ZCNT = 0
      DO 18 I = 1,NUMQTR
  18     IF (SMGC(I).EQ.'Z') ZCNT = ZCNT + 1
C**
      DO 20 I = 1,NUMQTR-1
C** HAS IT ENTERED OR LEFT THE SYSTEM (OR BOTH)?
         IF ((SMGC(I).EQ.'Z').AND.(SMGC(I+1).NE.'Z'))
     &      IENTER = ILEFT + 1
         IF ((SMGC(I).NE.'Z').AND.(SMGC(I+1).EQ.'Z'))
     &      ILEFT = IENTER + 1
C** IS IT IN SAME CATEGORY?
         IF (SMGC(I).EQ.SMGC(I+1)) GOTO 21
C**      ELSE:
C** COLLECT MIGRATION STATISTICS
            MIGCNT = MIGCNT + 1
            CATFRQ(6,CATCNT) = CATFRQ(6,CATCNT) + 1
            CATFRQ(CURCAT,CATCNT) = CATFRQ(CURCAT,CATCNT)+1
            CALL STATS(CATCNT,CFMEAN(6),CFVAR(6),CFCNT(6))
            K = CURCAT
            CALL STATS(CATCNT,CFMEAN(K),CFVAR(K),CFCNT(K))
            CATCNT = 1
            CURCAT = INDEX(SMGC(I+1))
C** COLLECT PERCENT CHANGE IN DEMAND STATS
            IF (PMDR(I).LT.0.01) GOTO 20
               DMDCHG=ABS((PMDR(I)-PMDR(I+1))/PMDR(I))*100.0
               IF (DMDCHG.GT.0.01) GOTO 22
                  INDX = 1
                  GOTO 23
```

```
 22           INDX = INT(ALOG(DMDCHG)) + 2
              IF (INDX.LT.1) INDX = 1
              IF (INDX.GT.6) INDX = 6
 23           CHGCNT(1,INDX) = CHGCNT(1,INDX) + 1
              GOTO 20
C**      THEN:
 21      CATCNT = CATCNT + 1
C** COLLECT PERCENT CHANGE IN DEMAND W/O MIGRATION STATS
        IF ((PMDR(I).EQ.PMDR(I+1)).OR.(PMDR(I).LT.0.01))
&             GOTO 20
           DCWNM=ABS((PMDR(I)-PMDR(I+1))/PMDR(I))*100.0
           IF (DCWNM.GT.0.01) GOTO 24
              INDX = 1
              GOTO 25
 24        INDX = INT(ALOG(DCWNM)) + 2
           IF (INDX.LT.1) INDX = 1
           IF (INDX.GT.6) INDX = 6
 25        CHGCNT(2,INDX) = CHGCNT(2,INDX) + 1
 20   CONTINUE
      IF (CATCNT.LT.12) GOTO 30
         CATFRQ(6,CATCNT) = CATFRQ(6,CATCNT) + 1
         CATFRQ(CURCAT,CATCNT) = CATFRQ(CURCAT,CATCNT) + 1
         CALL STATS(CATCNT,CFMEAN(6),CFVAR(6),CFCNT(6))
         K = CURCAT
         CALL STATS(CATCNT,CFMEAN(K),CFVAR(K),CFCNT(K))
 30   CONTINUE
C**
C** WRITE RECORDS W/HI MIGRATION TO NEW FILE **
      IF (MIGCNT.GT.3) WRITE(15)FSC,NIIN,(MIGREC(I),I=1,12)
C**
C**  SEE IF ITEM IS GOING IN AND OUT
      IF ((IENTER.EQ.0).OR.(ILEFT.EQ.0)) GOTO 45
C**   ELSE:
         IF (MOD(IENTER,2).EQ.0) GOTO 40
C**      ELSE:  OUT-IN-OUT
            OIOCNT = OIOCNT + 1
            WRITE(16)FSC,NIIN,(MIGREC(I),I=1,12)
            GOTO 45
C**      THEN:  IN-OUT-IN
 40         IOICNT = IOICNT + 1
            WRITE(17)FSC,NIIN,(MIGREC(I),I=1,12)
C**   THEN:
 45   CONTINUE
C**
C** COLLECT STATISTICS **
      CALL STATS(MIGCNT,MCMEAN,MCVAR,MCNT)
      CALL STATS((NUMQTR-ZCNT),NZMEAN,NZVAR,NZCNT)
      IF (ZCNT.LT.1) NOZCNT = NOZCNT + 1
      FREQCT(MIGCNT+1) = FREQCT(MIGCNT+1) + 1
      IF (MIGCNT.GT.0) MIGSUM = MIGSUM + 1
C**
C** FINISHED WITH ITEM, GET ANOTHER
      GOTO 1
```

```
C**
C** CLEAN UP VARIABLES **
  99  DO 50 I = 1,NUMQTR
          FREQSM = FREQSM + FREQCT(I)
          MAXFRQ = MAX(MAXFRQ,FREQCT(I))
          MINFRQ = MIN(MINFRQ,FREQCT(I))
          DO 50 J = 1,6
             CATSUM(J) = CATSUM(J) + CATFRQ(J,I)
             MAXCF(J) = MAX(MAXCF(J),CATFRQ(J,I))
             MINCF(J) = MIN(MINCF(J),CATFRQ(J,I))
  50  CONTINUE

C** ADJUST VARIANCES
      MCVAR = MCVAR/(MCNT -1)
      NZVAR = NZVAR/(NZCNT-1)
      DO 70 I = 1,6
  70      CFVAR(I) = CFVAR(I)/(CFCNT(I)-1)
C**
C** WRITE REPORT **
      WRITE(11,200)
      WRITE(11,205)NUMREC
      WRITE(11,206)DMPCNT
      WRITE(11,208)MIGSUM
      WRITE(11,210)NOZCNT
      WRITE(11,215)OIOCNT
      WRITE(11,220)IOICNT
      WRITE(11,225)
      WRITE(11,230)MCMEAN,MCVAR,SQRT(MCVAR)
      WRITE(11,235)
      WRITE(11,230)NZMEAN,NZVAR,SQRT(NZVAR)
      WRITE(11,236)
      WRITE(11,230)CFMEAN(6),CFVAR(6),SQRT(CFVAR(6))
      WRITE(11,237)
      WRITE(11,230)CFMEAN(1),CFVAR(1),SQRT(CFVAR(1))
      WRITE(11,238)
      WRITE(11,230)CFMEAN(2),CFVAR(2),SQRT(CFVAR(2))
      WRITE(11,239)
      WRITE(11,230)CFMEAN(3),CFVAR(3),SQRT(CFVAR(3))
      WRITE(11,240)
      WRITE(11,230)CFMEAN(4),CFVAR(4),SQRT(CFVAR(4))
      WRITE(11,241)
      WRITE(11,230)CFMEAN(5),CFVAR(5),SQRT(CFVAR(5))
      WRITE(11,245)
      WRITE(11,250)MAXFRQ,MINFRQ,FREQSM
      WRITE(11,255)
      WRITE(11,260)(I-1,FREQCT(I),I=1,NUMQTR)
      WRITE(11,265)
      WRITE(11,250)MAXCF(6),MINCF(6),CATSUM(6)
      WRITE(11,255)
      WRITE(11,260)(I,CATFRQ(6,I),I=1,NUMQTR)
      WRITE(11,285)
      WRITE(11,250)MAXCF(1),MINCF(1),CATSUM(1)
      WRITE(11,255)
```

```
      WRITE(11,260)(I,CATFRQ(1,I),I=1,NUMQTR)
      WRITE(11,305)
      WRITE(11,250)MAXCF(2),MINCF(2),CATSUM(2)
      WRITE(11,255)
      WRITE(11,260)(I,CATFRQ(2,I),I=1,NUMQTR)
      WRITE(11,325)
      WRITE(11,250)MAXCF(3),MINCF(3),CATSUM(3)
      WRITE(11,255)
      WRITE(11,260)(I,CATFRQ(3,I),I=1,NUMQTR)
      WRITE(11,345)
      WRITE(11,250)MAXCF(4),MINCF(4),CATSUM(4)
      WRITE(11,255)
      WRITE(11,260)(I,CATFRQ(4,I),I=1,NUMQTR)
      WRITE(11,365)
      WRITE(11,250)MAXCF(5),MINCF(5),CATSUM(5)
      WRITE(11,255)
      WRITE(11,260)(I,CATFRQ(5,I),I=1,NUMQTR)
      WRITE(11,385)
      WRITE(11,390)(CHGCNT(1,I),I=1,6)
      WRITE(11,395)
      WRITE(11,390)(CHGCNT(2,I),I=1,6)
  200 FORMAT(20X,'****  MIGRATION  ANALYSIS  REPORT  ****',/
     &         ' VERSION A',//)
  205 FORMAT(' NUMBER OF RECORDS PROCESSED    = ',I8)
  206 FORMAT(' NUMBER OF RECORDS DUMPED       = ',I8)
  208 FORMAT(' NUMBER OF ITEMS WHICH MIGRATED = ',I8)
  210 FORMAT(' NUMBER OF ITEMS ALWAYS IN      = ',I8,/)
  215 FORMAT(' # WHICH ENTERED & LEFT    = ',I7)
  220 FORMAT(' # WHICH LEFT & RE-ENTERED = ',I7,/)
  225 FORMAT(' NUMBER OF MIGRATIONS PER ITEM --')
  230 FORMAT('    MEAN =          ',F15.6,/,
     &         '    VARIANCE =      ',F15.6,/,
     &         '    STD DEV =       ',F15.6,//)
  231 FORMAT('    MEAN =          ',F15.6,/,
     &         '    VARIANCE =      ',F15.6,/,
     &         '    STD DEV =       ',F15.6,/,
     &         '    MAX CHANGE =    ',F15.6,/.
     &         '    MIN CHANGE =    ',F15.6,//)
  235 FORMAT(' NUMBER OF QUARTERS IN SYSTEM PER ITEM --')
  236 FORMAT(' NUMBER OF QUARTERS IN ALL CATAGORIES --')
  237 FORMAT(' NUMBER OF QUARTERS IN SMGC X (PER ITEM) --')
  238 FORMAT(' NUMBER OF QUARTERS IN SMGC T (PER ITEM) --')
  239 FORMAT(' NUMBER OF QUARTERS IN SMGC P (PER ITEM) --')
  240 FORMAT(' NUMBER OF QUARTERS IN SMGC M (PER ITEM) --')
  241 FORMAT(' NUMBER OF QUARTERS NOT IN SYSTEM --')
  245 FORMAT('1',20X,'MIGRATION  FREQUENCY  COUNT',/)
  250 FORMAT(' MAX CELL COUNT = ',I8,/,
     &         ' MIN CELL COUNT = ',I8,/,
     &         ' SUM ALL CELLS  = ',I8,/)
  255 FORMAT(' NUMBER OF',/,
     &         ' QUARTERS        COUNT',/)
  260 FORMAT(4X,I2,9X,I7)
  265 FORMAT('1',20X,'* QTRS IN SMGC FREQUENCY COUNT *',/,
```

```
&            36X,'ALL SMGCS',/)
 285   FORMAT('1',20X,'* QTRS IN SMGC FREQUENCY COUNT *',/,
&            38X,'SMGC  X',/)
 305   FORMAT('1',20X,'* QTRS IN SMGC FREQUENCY COUNT *',/,
&            38X,'SMGC  T',/)
 325   FORMAT('1',20X,'* QTRS IN SMGC FREQUENCY COUNT *',/,
&            38X,'SMGC  P',/)
 345   FORMAT('1',20X,'* QTRS IN SMGC FREQUENCY COUNT *',/,
&            38X,'SMGC  M',/)
 365   FORMAT('1',20X,'* QTRS IN SMGC FREQUENCY COUNT *',/,
&            34X,'NOT IN SYSTEM',/)
 385   FORMAT('1DEMAND CHANGE INDEX CNT FOR MIGRATING ITEMS')
 390   FORMAT('      0 TO      1 = ',I8,/,
&            '      1 TO     10 = ',I8,/,
&            '     10 TO    100 = ',I8,/,
&            '    100 TO   1000 = ',I8,/,
&            '   1000 TO  10000 = ',I8,/,
&            '  10000 TO    INF = ',I8)
 395   FORMAT(//,' DEMAND CHANGE INDEX CNT FOR NO MIGRATION')
       STOP
       END
C****   STATS   ****
       SUBROUTINE STATS(X,MEAN,VAR,COUNT)
       INTEGER X,COUNT
       REAL MEAN,VAR,D
C** ROUTINE USES THE PROVISIONAL MEANS ALGORITHM **
C** TO COMPUTE STATS **
       COUNT = COUNT + 1
       D = X - MEAN
       MEAN = MEAN + D/COUNT
       VAR = VAR + D*(X - MEAN)
       RETURN
       END
C****   INDEX   ****
       INTEGER FUNCTION INDEX(SMGC)
       CHARACTER SMGC*1
       IF (SMGC.EQ.'X') INDEX = 1
       IF (SMGC.EQ.'T') INDEX = 2
       IF (SMGC.EQ.'P') INDEX = 3
       IF (SMGC.EQ.'M') INDEX = 4
       IF (SMGC.EQ.'Z') INDEX = 5
       RETURN
       END
$:EXECUTE
$:LIMITS:400
$:FILE:10,Q1R
$:REMOTE:11
$:FILE:15,01S
$:FILE:16,02S
$:FILE:17,03S
$:UTILITY
$:LIMITS:400
$:FILE:I1,01R
```

```
#:FILE:I2,O2R
#:FILE:I3,O3R
#:TAPE9:OT,T2D,,92169,,MIGDATA2,,DEN62
#:FUTIL:I1,OT,RWD/I1,OT/,COPY/1F/
#:FUTIL:I2,OT,RWD/I2,OT/,SKIP/,1F/,COPY/1F/
#:FUTIL:I3,OT,RWD/I3,OT/,SKIP/,2F/,COPY/1F/
#:ENDJOB
,OT/,SKIP/,1F/,COPY/1F/
#:FUTIL:I3,OT,RWD/I3,OT/,SKIP/,2F/,COPY/1F/
#:ENDJOB
```

MIGSTATB

MIGSTATB does some further statistics collecting on the time-dependent migration data. It does the same data filtering as does MIGSTATA (except that it does not dump those records which are in for less than nine quarters), but it only considers the number of migrations from the lower two categories to the higher two and the number of original items remaining in a given SMCC at each quarter.

```
##NORM,R(X1)
#:IDENT:
#:LIMITS:350,35K,,10K
#:UTILITY
#:LIMITS:350
#:TAPE9:IN,T1D,,92160,,MIGDATA1,,DEN62
#:FILE:OT,Q1S
#:FUTIL:IN,OT,RWD/IN/,COPY/1F/,RWD/IN,OT/
#:OPTION:FORTRAN,NOMAP
#:FORTY:NODECK,NOMAP
C**  MIGSTATS  **
      CALL FXOPT(32,1,1,0)
      DIMENSION MIGREC(12),SMGC(12),PRICE(12),PMDR(12)
      CHARACTER NIIN*9,SMGC*1,MIGREC*20
      INTEGER FSC,NUMQTR,NUMREC,BACKUP,UPDOWN,UPTOHI,BUCNT,
&        UDCNT,UTHCNT,HICNT,LOCNT,NINCNT,LEFTCT,QTRCNT(4,12)
      REAL PRICE,PMDR
C** INITIALIZE VARIABLES **
      DATA QTRCNT/48*0/
      NUMQTR = 12
      BUCNT  = 0
      LEFTCT = 0
      HICNT  = 0
      LOCNT  = 0
      NINCNT = 0
      UDCNT  = 0
      UTHCNT = 0
C**
C**  READ FROM FILE  **
    1 READ(10,END = 99)FSC,NIIN,(MIGREC(I),I=1,12)
      NUMREC = NUMREC + 1
      DO 10 I = 1,12
   10   DECODE(MIGREC(I),100)SMGC(I),PRICE(I),PMDR(I)
  100 FORMAT(A1,2F9.2)
C**
C** COMPUTE STATISTICS AND WRITE REPORT **
C**
      BACKUP = 0
      UPDOWN = 0
      UPTOHI = 0
C**
C** ONLY CONSIDER ITEMS IN THE SYSTEM FROM THE START
      IF (SMGC(1).NE.'Z') GOTO 16
         NINCNT = NINCNT + 1
         GOTO 1
C**
   16 DO 17 I = 2,NUMQTR-1
         IF ((SMGC(I).NE.'Z').OR.
&           (SMGC(I-1).EQ.'Z').OR.(SMGC(I+1).EQ.'Z'))GOTO 17
            SMGC(I)  = SMGC(I-1)
            PRICE(I) = PRICE(I-1)
            PMDR(I)  = PMDR(I-1)
   17 CONTINUE
```

```
C**
      LEFTCT = LEFTCT + 1
      IF (HILOW(SMGC(1)).GT.O) GOTO 40
      I = 2
   20    IF (HILOW(SMGC(I)).GT.O) GOTO 25
         I = I+1
         IF (I.LE.NUMQTR) GOTO 20
   25 UPTOHI = I
C**
   30 DO 35 I = 2,NUMQTR
         IF ((I.GT.UPTOHI).AND.(HILOW(SMGC(I)).LT.1))
&           UPDOWN = 1
   35    IF ((UPDOWN.EQ.1).AND.(HILOW(SMGC(I)).GT.O))
&           BACKUP = 1
C**
   40 IF (HILOW(SMGC(1)).GT.O) HICNT = HICNT + 1
      IF (HILOW(SMGC(1)).LT.O) LOCNT = LOCNT + 1
      IF (UPTOHI.LE.NUMQTR) UTHCNT = UTHCNT + 1
      UDCNT = UDCNT + UPDOWN
      BUCNT = BUCNT + BACKUP
C**
      QTRCNT(INDEX(SMGC(1)),1) = QTRCNT(INDEX(SMGC(1)),1) + 1
      DO 50 I = 2,NUMQTR
         IF (SMGC(I).NE.SMGC(1)) GOTO 60
         QTRCNT(INDEX(SMGC(1)),I)=QTRCNT(INDEX(SMGC(1)),I)+1
   50 CONTINUE
C**
C** FINISHED WITH ITEM, GET ANOTHER
   60 GOTO 1
C**
C** DONE WITH FILE
   99 CONTINUE
C**
C** WRITE REPORT **
      WRITE(11,200)
      WRITE(11,205)NUMREC
      WRITE(11,206)NINCNT
      WRITE(11,207)DMPCNT
      WRITE(11,208)LEFTCT
      WRITE(11,209)HICNT
      WRITE(11,210)LOCNT
      WRITE(11,220)UTHCNT
      WRITE(11,230)UDCNT
      WRITE(11,240)BUCNT
      WRITE(11,250)(I,QTRCNT(1,I),I=1,NUMQTR)
      WRITE(11,255)(I,QTRCNT(2,I),I=1,NUMQTR)
      WRITE(11,260)(I,QTRCNT(3,I),I=1,NUMQTR)
      WRITE(11,265)(I,QTRCNT(4,I),I=1,NUMQTR)
  200 FORMAT(20X, '***  MIGRATION  ANALYSIS  REPORT  ***',/
&             ' VERSION B',//)
  205 FORMAT(' NUMBER OF RECORDS PROCESSED          = ',I8)
  206 FORMAT(' NUMBER OF RECORDS NOT IN FIRST QTR = ',I8)
  207 FORMAT(' NUMBER OF RECORDS DUMPED             = ',I8)
```

```
 208   FORMAT(' NUMBER OF RECORDS REMAINING          = ',I8)
 209   FORMAT(' NUMBER OF ITEMS WHICH STARTED HI     = ',I8)
 210   FORMAT(' NUMBER OF ITEMS WHICH STARTED LO     = ',I8)
 220   FORMAT(' NUMBER OF LOW MOVING TO HIGH         = ',I8)
 230   FORMAT(' NUMBER MOVING DOWN AGAIN             = ',I8)
 240   FORMAT(' NUMBER GOING UP ONCE AGAIN           = ',I8)
 250   FORMAT('1NUMber OF ORIGINAL ITEMS REMAINING IN X',/,
&           ' QTR          NUMBER REMAINING',/,
&             12(1X,I2,13X,I8,/))
 255   FORMAT(/' NUMBER OF ORIGINAL ITEMS REMAINING IN T',/,
&           ' QTR          NUMBER REMAINING',/,
&             12(1X,I2,13X,I8,/))
 260   FORMAT(/' NUMBER OF ORIGINAL ITEMS REMAINING IN P',/,
&           ' QTR          NUMBER REMAINING',/,
&             12(1X,I2,13X,I8,/))
 265   FORMAT(/' NUMBER OF ORIGINAL ITEMS REMAINING IN M',/,
&           ' QTR          NUMBER REMAINING',/,
&             12(1X,I2,13X,I8,/))
       STOP
       END
C****   HILOW   ****
       INTEGER FUNCTION HILOW(SMGC)
       CHARACTER SMGC*1
       HILOW = 0
       IF ((SMGC.EQ.'X').OR.(SMGC.EQ.'T')) HILOW = -1
       IF ((SMGC.EQ.'P').OR.(SMGC.EQ.'M')) HILOW =  1
       RETURN
       END
C****   INDEX   ****
       INTEGER FUNCTION INDEX(SMGC)
       CHARACTER SMGC*1
       IF (SMGC.EQ.'X') INDEX = 1
       IF (SMGC.EQ.'T') INDEX = 2
       IF (SMGC.EQ.'P') INDEX = 3
       IF (SMGC.EQ.'M') INDEX = 4
       RETURN
       END
#:EXECUTE
#:LIMITS:350
#:FILE:10,Q1R
#:REMOTE:11
#:ENDJOB
```

APPENDIX C

Migration Reports

The migration reports presented here were generated from the program MATCHxx, where "xx" is the starting quarter of the period being matched. File "A" is the starting quarter, and file "B" is the ending quarter. The line "TOTAL NUMBER OF ITEMS" gives the total number of unique items between the two files. The line "BY SMGC" gives the number of items in each SMGC in ascending order (i.e., X, T, P, M). The table lists the number of items migrating from on SMGC to another. The indexes were computed using the formulas described in Chapter 3.

**** MIGRATION REPORT ****

Quarter 2 to 3

ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 104614
NUMBER OF RECORDS PROCESSED FROM FILE B = 105662
TOTAL NUMBER OF ITEMS = 106154
MISMATCH INDEX = 0.00470

BY SMGC IN A	78983	16711	7578	1342
BY SMGC IN B	79852	16752	7676	1382

FROM\TO	X	T	P	M	O
X	77807	701	61	8	406
T	549	15789	335	1	37
P	13	237	7201	100	27
M	0	2	63	1256	21
I	1484	23	16	17	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98511	0.94483	0.95025	0.93592	0.95403

**** MIGRATION REPORT ****

Quarter 2 to 3

ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 92234
NUMBER OF RECORDS PROCESSED FROM FILE B = 93799
TOTAL NUMBER OF ITEMS = 130441
MISMATCH INDEX = 0.39727

BY SMGC IN A	75652	11692	4280	610
BY SMGC IN B	72064	14424	6320	991

FROM\TO	X	T	P	M	C
X	43479	295	38	4	31836
T	223	7687	114	1	3667
P	12	94	3114	21	1039
M	4	1	10	496	99
I	28347	6347	3044	469	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.57472	0.65746	0.72757	0.81311	0.69322

**** MIGRATION REPORT ****
Quarter 2 to 3
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 90841
NUMBER OF RECORDS PROCESSED FROM FILE B = 89269
TOTAL NUMBER OF ITEMS = 92226
MISMATCH INDEX = 0.01551

BY SMGC IN A	77309	10234	3018	280
BY SMGC IN B	75941	10087	2964	277

FROM\TO	X	T	P	M	O
X	74065	461	40	3	2740
T	497	9433	169	1	134
P	12	181	2732	24	69
M	1	0	19	247	13
I	1367	12	4	2	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.95804	0.92173	0.90524	0.88214	0.91679

**** MIGRATION REPORT ****
Quarter 3 to 4
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 105662
NUMBER OF RECORDS PROCESSED FROM FILE B = 106181
TOTAL NUMBER OF ITEMS = 106989
MISMATCH INDEX = 0.00765

BY SMGC IN A	79852	16752	7676	1382
BY SMGC IN B	79955	16971	7828	1427

FROM\TO	X	T	P	M	O
X	78128	914	88	11	711
T	568	15764	364	2	54
P	18	246	7272	103	37
M	13	1	71	1292	5
I	1229	46	33	19	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97841	0.94102	0.94737	0.93488	0.95042

**** MIGRATION REPORT ****
Quarter 3 to 4
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 93799
NUMBER OF RECORDS PROCESSED FROM FILE B = 94612
TOTAL NUMBER OF ITEMS = 132644
MISMATCH INDEX = 0.40546

BY SMGC IN A	72064	14423	6320	991
BY SMGC IN B	77577	11982	4431	623

FROM\TO	X	T	P	M	O
X	43412	482	40	9	28122
T	393	7457	206	2	6366
P	25	140	3048	37	3069
M	5	2	33	476	475
I	33742	3901	1104	98	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.60241	0.51702	0.48228	0.48032	0.52051

**** MIGRATION REPORT ****
Quarter 3 to 4
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 89269
NUMBER OF RECORDS PROCESSED FROM FILE B = 90087
TOTAL NUMBER OF ITEMS = 90710
MISMATCH INDEX = 0.00698

BY SMGC IN A	75941	10087	2964	277
BY SMGC IN B	76733	10147	2901	306

FROM\TO	X	T	P	M	O
X	74663	674	44	5	555
T	630	9258	153	1	45
P	18	206	2683	39	18
M	0	0	14	259	4
I	1423	9	7	2	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98317	0.91782	0.90520	0.93502	0.93530

**** MIGRATION REPORT ****
Quarter 3 to 4
ALC WR

NUMBER OF RECORDS PROCESSED FROM FILE A = 156943
NUMBER OF RECORDS PROCESSED FROM FILE B = 158416
TOTAL NUMBER OF ITEMS = 159525
MISMATCH INDEX = 0.00707

BY SMGC IN A	132859	16940	6284	860
BY SMGC IN B	134216	16986	6326	888

FROM\TO	X	T	P	M	O
X	130831	923	69	15	1021
T	832	15749	310	2	47
P	20	279	5901	61	23
M	3	6	34	799	18
I	2530	29	12	11	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98474	0.92969	0.93905	0.92907	0.94564

**** MIGRATION REPORT ****
Quarter 4 to 5
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 106181
NUMBER OF RECORDS PROCESSED FROM FILE B = 106968
TOTAL NUMBER OF ITEMS = 107452
MISMATCH INDEX = 0.00456

BY SMGC IN A	79955	16971	7828	1427
BY SMGC IN B	80329	17222	7942	1475

FROM\TO	X	T	P	M	O
X	78567	900	91	15	382
T	542	15992	390	2	45
P	20	302	7373	92	41
M	1	2	50	1359	15
I	1200	26	38	7	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98264	0.94231	0.94188	0.95235	0.95479

**** MIGRATION REPORT ****
Quarter 4 to 5
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 94612
NUMBER OF RECORDS PROCESSED FROM FILE B = 89976
TOTAL NUMBER OF ITEMS = 96465
MISMATCH INDEX = 0.02059

BY SMGC IN A	77577	11982	4431	622
BY SMGC IN B	73488	11575	4278	635

FROM\TO	X	T	P	M	O
X	71253	853	98	12	5361
T	419	10510	205	1	847
P	13	181	3940	39	258
M	1	0	19	580	22
I	1803	31	16	3	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.91848	0.87715	0.88919	0.93248	0.90432

**** MIGRATION REPORT ****
Quarter 4 to 5
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 171363
NUMBER OF RECORDS PROCESSED FROM FILE B = 166439
TOTAL NUMBER OF ITEMS = 174130
MISMATCH INDEX = 0.01662

BY SMGC IN A	139011	22557	8391	1404
BY SMGC IN B	134595	22239	8207	1398

FROM\TO	X	T	P	M	O
X	131096	1133	123	7	6652
T	772	20708	392	2	683
P	35	362	7611	87	296
M	6	1	43	1294	60
I	2686	35	38	8	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.94306	0.91803	0.90704	0.92165	0.92245

**** MIGRATION REPORT ****
Quarter 4 to 5
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 90087
NUMBER OF RECORDS PROCESSED FROM FILE B = 91279
TOTAL NUMBER OF ITEMS = 92138
MISMATCH INDEX = 0.00954

BY SMGC IN A	76733	10147	2901	306
BY SMGC IN B	77698	10290	2976	315

FROM\TO	X	T	P	M	O
X	75278	588	66	1	800
T	452	9484	168	1	42
P	8	145	2711	23	14
M	0	0	15	289	2
I	1961	73	16	1	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98104	0.93466	0.93451	0.94444	0.94866

**** MIGRATION REPORT ****
Quarter 5 to 6
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 106968
NUMBER OF RECORDS PROCESSED FROM FILE B = 107579
TOTAL NUMBER OF ITEMS = 108139
MISMATCH INDEX = 0.00524

BY SMGC IN A	80329	17222	7942	1475
BY SMGC IN B	79661	17691	8552	1675

FROM\TO	X	T	P	M	O
X	77899	1829	99	19	483
T	613	15482	1082	7	38
P	24	352	7271	277	18
M	3	2	94	1356	20
I	1123	26	6	16	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97788	0.89897	0.91551	0.91932	0.92792

**** MIGRATION REPORT ****
Quarter 5 to 6
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 89976
NUMBER OF RECORDS PROCESSED FROM FILE B = 94656
TOTAL NUMBER OF ITEMS = 95210
MISMATCH INDEX = 0.00616

BY SMGC IN A	73488	11575	4278	635
BY SMGC IN B	76540	12604	4780	732

FROM\TO	X	T	P	M	O
X	71713	1191	80	11	493
T	558	10443	529	5	40
P	22	264	3860	115	17
M	0	2	44	586	3
I	4248	704	267	15	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97585	0.90220	0.90229	0.92283	0.92579

**** MIGRATION REPORT ****
Quarter 5 to 6
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 166439
NUMBER OF RECORDS PROCESSED FROM FILE B = 172391
TOTAL NUMBER OF ITEMS = 173602
MISMATCH INDEX = 0.00728

BY SMGC IN A	134595	22239	8207	1398
BY SMGC IN B	138541	23328	8922	1600

FROM\TO	X	T	P	M	O
X	131441	1892	112	10	1140
T	845	20369	977	12	36
P	36	421	7508	213	29
M	0	1	69	1322	6
I	6219	645	256	43	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97657	0.91591	0.91483	0.94564	0.93824

**** MIGRATION REPORT ****
Quarter 5 to 6
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 91279
NUMBER OF RECORDS PROCESSED FROM FILE B = 91386
TOTAL NUMBER OF ITEMS = 92722
MISMATCH INDEX = 0.01464

BY SMGC IN A	77698	10290	2976	315
BY SMGC IN B	76908	10730	3351	397

FROM\TO	X	T	P	M	O
X	74961	1413	100	8	1216
T	526	9105	566	0	93
P	11	192	2657	94	22
M	1	2	17	291	4
I	1410	18	11	4	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97468	0.88484	0.89281	0.92381	0.91904

**** MIGRATION REPORT ****
Quarter 6 to 7
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 107579
NUMBER OF RECORDS PROCESSED FROM FILE B = 108352
TOTAL NUMBER OF ITEMS = 109026
MISMATCH INDEX = 0.00627

BY SMGC IN A	79661	17691	8552	1675
BY SMGC IN B	80204	17843	8574	1731

FROM\TO	X	T	P	M	O
X	78188	819	62	23	569
T	625	16620	397	2	47
P	20	373	7991	122	46
M	1	0	92	1571	11
I	1371	31	32	13	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98151	0.93946	0.93440	0.93791	0.94832

**** MIGRATION REPORT ****
Quarter 6 to 7
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 94656
NUMBER OF RECORDS PROCESSED FROM FILE B = 97464
TOTAL NUMBER OF ITEMS = 97957
MISMATCH INDEX = 0.00521

BY SMGC IN A	76540	12604	4780	732
BY SMGC IN B	78599	13024	5085	756

FROM\TO	X	T	P	M	O
X	75255	780	89	7	409
T	476	11759	324	0	45
P	7	166	4522	63	22
M	2	4	35	675	16
I	2860	315	115	11	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98321	0.93296	0.94603	0.92213	0.94608

**** MIGRATION REPORT ****
Quarter 6 to 7
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 172391
NUMBER OF RECORDS PROCESSED FROM FILE B = 173786
TOTAL NUMBER OF ITEMS = 174969
MISMATCH INDEX = 0.00686

BY SMGC IN A	138541	23328	8922	1600
BY SMGC IN B	139132	23820	9108	1726

FROM\TO	X	T	P	M	O
X	135529	1736	186	34	1056
T	1068	21588	592	3	77
P	49	430	8258	147	38
M	5	2	47	1535	11
I	2482	64	25	7	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97826	0.92541	0.92558	0.95938	0.94716

**** MIGRATION REPORT ****

Quarter 7 to 8

ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 108352
NUMBER OF RECORDS PROCESSED FROM FILE B = 103816
TOTAL NUMBER OF ITEMS = 109434
MISMATCH INDEX = 0.01042

BY SMGC IN A	80204	17843	8574	1731
BY SMGC IN B	76720	17138	8246	1712

FROM\TO	X	T	P	M	O
X	75100	829	69	5	4201
T	620	15947	370	0	905
P	22	320	7704	97	431
M	0	0	60	1592	79
I	979	42	43	18	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.93636	0.89374	0.89853	0.91970	0.91208

**** MIGRATION REPORT ****

Quarter 7 to 8

ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 97464
NUMBER OF RECORDS PROCESSED FROM FILE B = 94290
TOTAL NUMBER OF ITEMS = 99432
MISMATCH INDEX = 0.02087

BY SMGC IN A	78599	13024	5085	756
BY SMGC IN B	75841	12721	4969	759

FROM\TO	X	T	P	M	O
X	73282	625	72	8	4612
T	639	11771	225	3	386
P	22	282	4614	43	124
M	1	1	36	699	19
I	1398	42	22	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.93235	0.90379	0.90737	0.92460	0.91703

**** MIGRATION REPORT ****
Quarter 7 to 8
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 173786
NUMBER OF RECORDS PROCESSED FROM FILE B = 166820
TOTAL NUMBER OF ITEMS = 176722
MISMATCH INDEX = 0.01760

BY SMGC IN A	139132	23820	9108	1726
BY SMGC IN B	132713	23255	9066	1786

FROM\TO	X	T	P	M	O
X	129023	1404	126	18	8561
T	824	21458	526	3	1009
P	36	319	8341	117	295
M	7	2	42	1639	36
I	2824	72	31	9	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.92734	0.90084	0.91579	0.94950	0.92339

**** MIGRATION REPORT ****
Quarter 7 to 8
ALC WR

NUMBER OF RECORDS PROCESSED FROM FILE A = 162916
NUMBER OF RECORDS PROCESSED FROM FILE B = 158683
TOTAL NUMBER OF ITEMS = 165682
MISMATCH INDEX = 0.01743

BY SMGC IN A	136803	18076	6938	1099
BY SMGC IN B	133314	17396	6897	1076

FROM\TO	X	T	P	M	O
X	129842	947	108	6	5900
T	754	16091	396	2	833
P	34	307	6289	71	237
M	14	3	64	990	28
I	2671	48	40	7	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.94912	0.89019	0.90646	0.90082	0.91164

**** MIGRATION REPORT ****
Quarter 8 to 9
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 103816
NUMBER OF RECORDS PROCESSED FROM FILE B = 97960
TOTAL NUMBER OF ITEMS = 104643
MISMATCH INDEX = 0.00844

BY SMGC IN A	76720	17138	8246	1712
BY SMGC IN B	72435	15970	7870	1685

FROM\TO	X	T	P	M	O
X	71065	507	60	7	5081
T	592	15138	260	2	1146
P	26	283	7468	71	398
M	2	1	64	1588	57
I	751	41	18	17	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98109	0.94790	0.94892	0.94243	0.95509

**** MIGRATION REPORT ****
Quarter 8 to 9
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 94290
NUMBER OF RECORDS PROCESSED FROM FILE B = 88681
TOTAL NUMBER OF ITEMS = 96325
MISMATCH INDEX = 0.02295

BY SMGC IN A	75841	12721	4969	759
BY SMGC IN B	71215	12029	4710	727

FROM\TO	X	T	P	M	O
X	68571	535	59	9	6667
T	672	11146	168	0	735
P	18	295	4415	44	197
M	2	2	43	668	44
I	1953	51	25	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.96287	0.92659	0.93737	0.91884	0.93642

**** MIGRATION REPORT ****

Quarter 8 to 9

ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 166820
NUMBER OF RECORDS PROCESSED FROM FILE B = 101067
TOTAL NUMBER OF ITEMS = 169242
MISMATCH INDEX = 0.02396

BY SMGC IN A	132713	23255	9066	1786
BY SMGC IN B	84013	11989	4471	594

FROM\TO	X	T	P	M	O
X	80988	471	47	6	51201
T	606	11334	151	1	11163
P	42	161	4229	35	4599
M	6	2	22	544	1212
I	2371	21	22	8	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.96399	0.94537	0.94587	0.91582	0.94276

**** MIGRATION REPORT ****

Quarter 8 to 9

ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 82974
NUMBER OF RECORDS PROCESSED FROM FILE B = 78624
TOTAL NUMBER OF ITEMS = 85212
MISMATCH INDEX = 0.02846

BY SMGC IN A	69047	10259	3281	387
BY SMGC IN B	65343	9590	3319	372

FROM\TO	X	T	P	M	O
X	62644	532	239	9	5623
T	526	8838	172	2	721
P	24	163	2851	25	218
M	3	0	29	330	25
I	2147	57	28	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.95869	0.92158	0.86894	0.88710	0.90908

**** MIGRATION REPORT ****
Quarter 8 to 9
ALC WR

NUMBER OF RECORDS PROCESSED FROM FILE A = 158683
NUMBER OF RECORDS PROCESSED FROM FILE B = 101892
TOTAL NUMBER OF ITEMS = 160681
MISMATCH INDEX = 0.01961

BY SMGC IN A	133314	17396	6897	1076
BY SMGC IN B	87042	10164	4011	675

FROM\TO	X	T	P	M	O
X	84516	496	47	17	48238
T	529	9447	134	1	7285
P	30	197	3791	30	2849
M	7	0	31	621	417
I	1960	24	8	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97098	0.92946	0.94515	0.92000	0.94140

**** MIGRATION REPORT ****
Quarter 9 to 10
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 97960
NUMBER OF RECORDS PROCESSED FROM FILE B = 94514
TOTAL NUMBER OF ITEMS = 99192
MISMATCH INDEX = 0.01304

BY SMGC IN A	72435	15970	7870	1685
BY SMGC IN B	68603	15679	8273	1959

FROM\TO	X	T	P	M	O
X	66762	1962	153	16	3542
T	690	13312	1255	15	698
P	23	346	6754	423	324
M	2	4	83	1483	113
I	1127	55	28	22	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.92168	0.83356	0.85820	0.88012	0.87339

**** MIGRATION REPORT ****
Quarter 9 to 10
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 101067
NUMBER OF RECORDS PROCESSED FROM FILE B = 101553
TOTAL NUMBER OF ITEMS = 109333
MISMATCH INDEX = 0.07698

BY SMGC IN A	84013	11989	4471	594
BY SMGC IN B	83717	12362	4813	661

FROM\TO	X	T	P	M	O
X	76021	1255	107	12	6618
T	510	10042	582	6	849
P	42	219	3828	110	272
M	4	1	44	505	40
I	7141	845	252	28	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.90487	0.83760	0.85618	0.85017	0.86221

**** MIGRATION REPORT ****
Quarter 9 to 10
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 78624
NUMBER OF RECORDS PROCESSED FROM FILE B = 74882
TOTAL NUMBER OF ITEMS = 79896
MISMATCH INDEX = 0.01699

BY SMGC IN A	65343	9590	3319	372
BY SMGC IN B	61287	9626	3548	421

FROM\TO	X	T	P	M	O
X	59620	1291	95	8	4329
T	440	8091	527	6	526
P	18	207	2878	75	141
M	1	2	26	326	17
I	1209	35	22	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.91242	0.84369	0.86713	0.87634	0.87490

**** MIGRATION REPORT ****
Quarter 10 to 11
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 94514
NUMBER OF RECORDS PROCESSED FROM FILE B = 67602
TOTAL NUMBER OF ITEMS = 95572
MISMATCH INDEX = 0.01565

BY SMGC IN A	68603	15679	8273	1959
BY SMGC IN B	51113	10304	5157	1028

FROM\TO	X	T	P	M	O
X	49590	470	46	8	18489
T	466	9641	222	3	5347
P	27	181	4851	52	3162
M	3	1	24	959	972
I	1027	11	14	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.72285	0.61490	0.58637	0.48954	0.60341

**** MIGRATION REPORT ****
Quarter 10 to 11
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 101553
NUMBER OF RECORDS PROCESSED FROM FILE B = 153402
TOTAL NUMBER OF ITEMS = 154131
MISMATCH INDEX = 0.00718

BY SMGC IN A	83717	12362	4813	661
BY SMGC IN B	121166	20992	9131	2113

FROM\TO	X	T	P	M	O
X	82082	863	65	19	688
T	1024	10938	373	2	25
P	158	144	4415	82	14
M	6	0	22	632	1
I	37897	9047	4256	1378	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98047	0.88481	0.91731	0.95613	0.93468

**** MIGRATION REPORT ****
Quarter 10 to 11
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 74882
NUMBER OF RECORDS PROCESSED FROM FILE B = 75933
TOTAL NUMBER OF ITEMS = 76324
MISMATCH INDEX = 0.00522

BY SMGC IN A	61287	9626	3548	421
BY SMGC IN B	62191	9694	3618	430

FROM\TO	X	T	P	M	O
X	60183	680	85	3	336
T	525	8852	216	0	33
P	56	148	3293	33	18
M	5	0	19	393	4
I	1422	14	5	1	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98199	0.91959	0.92813	0.93349	0.94080

**** MIGRATION REPORT ****
Quarter 11 to 12
ALC 00

NUMBER OF RECORDS PROCESSED FROM FILE A = 87705
NUMBER OF RECORDS PROCESSED FROM FILE B = 89575
TOTAL NUMBER OF ITEMS = 90192
MISMATCH INDEX = 0.00703

BY SMGC IN A	70197	11664	5013	831
BY SMGC IN B	71840	11781	5103	851

FROM\TO	X	T	P	M	O
X	68890	637	96	13	561
T	499	10908	229	0	28
P	18	205	4726	42	22
M	1	1	32	792	5
I	2433	30	20	4	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98138	0.9[illegible]19	0.94275	0.95307	0.95310

**** MIGRATION REPORT ****
Quarter 11 to 12
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 153402
NUMBER OF RECORDS PROCESSED FROM FILE B = 175155
TOTAL NUMBER OF ITEMS = 175860
MISMATCH INDEX = 0.00460

BY SMGC IN A	121[illegible]66	20992	9131	2113
BY SMGC IN B	142083	21527	9393	2152

FROM\TO	X	T	P	M	O
X	118997	1381	166	27	595
T	694	19766	485	0	47
P	33	330	8626	102	40
M	2	2	78	2009	22
I	22358	48	38	14	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98210	0.94160	0.94469	0.95078	0.95479

**** MIGRATION REPORT ****
Quarter 11 to 12
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 75933
NUMBER OF RECORDS PROCESSED FROM FILE B = 77534
TOTAL NUMBER OF ITEMS = 78040
MISMATCH INDEX = 0.00666

BY SMGC IN A	62191	9694	3618	430
BY SMGC IN B	63498	9894	3713	429

FROM\TO	X	T	P	M	O
X	61041	601	77	4	468
T	352	9107	215	0	20
P	24	166	3383	31	14
M	3	0	33	391	3
I	2079	20	5	3	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98151	0.93945	0.93505	0.91142	0.94186

**** MIGRATION REPORT ****
Quarter 12 to 13
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 89575
NUMBER OF RECORDS PROCESSED FROM FILE B = 90035
TOTAL NUMBER OF ITEMS = 90617
MISMATCH INDEX = 0.00650

BY SMGC IN A	71840	11781	5103	851
BY SMGC IN B	72132	11894	5141	868

FROM\TO	X	T	P	M	O
X	70544	671	122	16	487
T	584	10962	191	2	42
P	24	227	4763	48	41
M	5	1	41	793	11
I	976	33	24	9	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98196	0.93048	0.93337	0.93184	0.94441

**** MIGRATION REPORT ****
Quarter 12 to 13
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 175155
NUMBER OF RECORDS PROCESSED FROM FILE B = 169422
TOTAL NUMBER OF ITEMS = 177955
MISMATCH INDEX = 0.01653

BY SMGC IN A	142083	21527	9393	2152
BY SMGC IN B	136733	21343	9273	2073

FROM\TO	X	T	P	M	O
X	133280	1482	270	15	7036
T	773	19358	386	4	1006
P	25	403	8497	81	387
M	6	0	77	1966	103
I	2650	100	43	7	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97475	0.90700	0.91632	0.94838	0.93661

**** MIGRATION REPORT ****
Quarter 12 to 13
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 77534
NUMBER OF RECORDS PROCESSED FROM FILE B = 78270
TOTAL NUMBER OF ITEMS = 79039
MISMATCH INDEX = 0.00992

BY SMGC IN A	63498	9894	3713	429
BY SMGC IN B	64125	10013	3694	438

FROM\TO	X	T	P	M	O
X	62265	536	52	5	640
T	457	9172	169	1	95
P	19	209	3430	27	28
M	1	0	20	403	5
I	1384	96	23	2	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.98058	0.92703	0.92853	0.93939	0.94388

**** MIGRATION REPORT ****
Quarter 13 to 14
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 98945
NUMBER OF RECORDS PROCESSED FROM FILE B = 90689
TOTAL NUMBER OF ITEMS = 100828
MISMATCH INDEX = 0.02076

BY SMGC IN A	72292	15913	8664	2076
BY SMGC IN B	63349	16348	8847	2145

FROM\TO	X	T	P	M	O
X	60792	1801	162	10	9527
T	692	13930	879	5	407
P	33	585	7624	246	176
M	4	4	162	1878	28
I	1829	28	20	6	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.95964	0.87538	0.87996	0.90462	0.90490

**** MIGRATION REPORT ****
Quarter 13 to 14
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 90035
NUMBER OF RECORDS PROCESSED FROM FILE B = 77488
TOTAL NUMBER OF ITEMS = 91299
MISMATCH INDEX = 0.01631

BY SMGC IN A	72132	11894	5141	868
BY SMGC IN B	59154	12068	5336	930

FROM\TO	X	T	P	M	O
X	57343	1407	169	14	13199
T	593	10202	635	12	452
P	28	414	4444	116	139
M	1	3	70	773	21
I	1189	42	18	15	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.96938	0.85774	0.86442	0.89055	0.89553

**** MIGRATION REPORT ****
Quarter 13 to 14
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 169422
NUMBER OF RECORDS PROCESSED FROM FILE B = 164186
TOTAL NUMBER OF ITEMS = 178570
MISMATCH INDEX = 0.05572

BY SMGC IN A	136733	21343	9273	2073
BY SMGC IN B	127968	23450	10468	2300

FROM\TO	X	T	P	M	O
X	119406	3335	425	30	13537
T	796	18626	1354	11	556
P	48	492	8191	315	227
M	24	6	127	1852	64
I	7694	991	371	92	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.93309	0.87270	0.88332	0.89339	0.89562

**** MIGRATION REPORT ****
Quarter 13 to 14
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 78270
NUMBER OF RECORDS PROCESSED FROM FILE B = 71670
TOTAL NUMBER OF ITEMS = 79910
MISMATCH INDEX = 0.02288

BY SMGC IN A	64125	10013	3694	438
BY SMGC IN B	56858	10313	4026	473

FROM\TO	X	T	P	M	O
X	54775	1303	133	10	7904
T	457	8777	534	2	243
P	22	204	3323	73	72
M	1	1	31	385	20
I	1604	28	5	3	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.96336	0.87656	0.89957	0.87900	0.90462

**** MIGRATION REPORT ****
Quarter 14 to 15
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 90689
NUMBER OF RECORDS PROCESSED FROM FILE B = 93514
TOTAL NUMBER OF ITEMS = 94435
MISMATCH INDEX = 0.01016

BY SMGC IN A	63349	16348	8847	2145
BY SMGC IN B	65957	16331	9019	2207

FROM\TO	X	T	P	M	O
X	61611	798	91	14	835
T	596	15256	440	1	55
P	49	253	8392	126	27
M	3	2	73	2063	4
I	3698	22	23	3	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.97256	0.93417	0.94857	0.96177	0.95427

**** MIGRATION REPORT ****
Quarter 14 to 15
ALC 00

NUMBER OF RECORDS PROCESSED FROM FILE A = 77488
NUMBER OF RECORDS PROCESSED FROM FILE B = 78712
TOTAL NUMBER OF ITEMS = 79405
MISMATCH INDEX = 0.00894

BY SMGC IN A	59154	12068	5336	930
BY SMGC IN B	59934	12370	5443	965

FROM\TO	X	T	P	M	O
X	57585	791	139	28	611
T	451	11358	216	1	42
P	19	191	5045	52	29
M	4	4	31	881	10
I	1875	26	13	3	0

MIGRATION INDEY BY SMGC:

X	T	P	M	AVG
0.97348	0.94117	0.94546	0.94731	0.95185

**** MIGRATION REPORT ****
Quarter 14 to 15
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 164186
NUMBER OF RECORDS PROCESSED FROM FILE B = 132629
TOTAL NUMBER OF ITEMS = 167321
MISMATCH INDEX = 0.02364

BY SMGC IN A	127968	23450	10468	2300
BY SMGC IN B	102372	19306	8772	2179

FROM\TO	X	T	P	M	O
X	98591	962	88	32	28295
T	662	18020	392	1	4375
P	33	288	8237	99	1811
M	4	1	41	2043	211
I	3082	35	14	4	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.96307	0.93339	0.93901	0.93759	0.94326

*** MIGRATION REPORT ****
Quarter 18 to 19
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 99008
NUMBER OF RECORDS PROCESSED FROM FILE B = 99818
TOTAL NUMBER OF ITEMS = 102992
MISMATCH INDEX = 0.03206

BY SMGC IN A	87691	9336	1981
BY SMGC IN B	79743	17769	2306

FROM\TO	T	P	M	O
T	76325	7962	303	3101
P	88	9097	92	59
M	10	94	1863	14
I	3320	616	48	0

MIGRATION INDEX BY SMGC:

T	P	M	AVG
0.95714	0.97440	0.94043	0.95732

**** MIGRATION REPORT ****
Quarter 18 to 19
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 79943
NUMBER OF RECORDS PROCESSED FROM FILE B = 80174
TOTAL NUMBER OF ITEMS = 81801
MISMATCH INDEX = 0.02035

BY SMGC IN A	73756	5322	865
BY SMGC IN B	65896	13103	1175

FROM\TO	T	P	M	O
T	64314	7639	218	1585
P	75	5089	121	37
M	24	31	805	5
I	1483	344	31	0

MIGRATION INDEX BY SMGC:

T	P	M	AVG
0.97599	0.95622	0.93064	0.95428

**** MIGRATION REPORT ****
Quarter 18 to 19
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 73453
NUMBER OF RECORDS PROCESSED FROM FILE B = 73030
TOTAL NUMBER OF ITEMS = 75410
MISMATCH INDEX = 0.02680

BY SMGC IN A	69129	3923	401
BY SMGC IN B	64742	7813	475

FROM\TO	T	P	M	O
T	62761	3936	83	2349
P	100	3770	33	20
M	6	33	352	10
I	1876	74	7	0

MIGRATION INDEX BY SMGC:

T	P	M	AVG
0.96940	0.96100	0.87781	0.93607

**** MIGRATION REPORT ****
Quarter 4 to quarter 8
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 106181
NUMBER OF RECORDS PROCESSED FROM FILE B = 103816
TOTAL NUMBER OF ITEMS = 109795
MISMATCH INDEX = 0.03481

BY SMGC IN A	79955	16971	7828	1427
BY SMGC IN B	76720	17138	8246	1712

FROM\TO	X	T	P	M	O
X	71400	3782	266	55	4452
T	1995	12307	1702	11	956
P	73	882	5966	434	473
M	1	1	172	1156	97
I	3252	166	140	56	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.93066	0.72518	0.76214	0.81009	0.80702

**** MIGRATION REPORT ****
Quarter 4 to quarter 8
ALC OO

NUMBER OF RECORDS PROCESSED FROM FILE A = 94612
NUMBER OF RECORDS PROCESSED FROM FILE B = 94290
TOTAL NUMBER OF ITEMS = 100124
MISMATCH INDEX = 0.05846

BY SMGC IN A	77577	11982	4431	622
BY SMGC IN B	75841	12721	4969	759

FROM\TO	X	T	P	M	O
X	68825	3149	295	32	5276
T	1783	8772	1036	11	380
P	78	586	3427	195	145
M	10	4	83	493	32
I	5146	210	128	28	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.90749	0.73210	0.77341	0.79260	0.80140

**** MIGRATION REPORT ****
Quarter 4 to quarter 8
ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A = 171363
NUMBER OF RECORDS PROCESSED FROM FILE B = 166820
TOTAL NUMBER OF ITEMS = 179036
MISMATCH INDEX = 0.04600

BY SMGC IN A	139011	22557	8391	1404
BY SMGC IN B	132713	23255	9066	1786

FROM\TO	X	T	P	M	O
X	122408	5398	463	57	10685
T	2971	16509	1962	17	1098
P	148	1043	6379	455	366
M	10	9	115	1204	66
I	7177	296	147	53	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.92235	0.73188	0.76022	0.85755	0.81800

**** MIGRATION REPORT ****
Quarter 4 to quarter 8
ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A = 90087
NUMBER OF RECORDS PROCESSED FROM FILE B = 82974
TOTAL NUMBER OF ITEMS = 94979
MISMATCH INDEX = 0.05896

BY SMGC IN A	76733	10147	2901	306
BY SMGC IN B	69047	10259	3281	387

FROM\TO	X	T	P	M	O
X	62747	2854	227	13	10892
T	1589	6818	827	3	910
P	41	430	2124	125	181
M	2	3	47	233	21
I	4669	154	56	13	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.90876	0.67192	0.73216	0.76144	0.76857

**** MIGRATION REPORT ****
Quarter 5 to quarter 9
ALC OC

NUMBER OF RECORDS PROCESSED FROM FILE A = 106968
NUMBER OF RECORDS PROCESSED FROM FILE B = 97960
TOTAL NUMBER OF ITEMS = 110279
MISMATCH INDEX = 0.03380

BY SMGC IN A	80329	17222	7942	1475
BY SMGC IN B	72435	15970	7870	1685

FROM\TO	X	T	P	M	O
X	67440	3234	220	42	9393
T	1947	11721	1552	12	1990
P	76	848	5803	412	803
M	3	2	180	1158	132
I	2970	165	115	61	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.93104	0.73394	0.73736	0.78508	0.79686

**** MIGRATION REPORT ****
Quarter 5 to quarter 9
ALC 00

NUMBER OF RECORDS PROCESSED FROM FILE A = 89976
NUMBER OF RECORDS PROCESSED FROM FILE B = 88681
TOTAL NUMBER OF ITEMS = 100341
MISMATCH INDEX = 0.11688

BY SMGC IN A	73488	11575	4278	635
BY SMGC IN B	71215	12029	4710	727

FROM\TO	X	T	P	M	O
X	60738	2276	183	14	10277
T	1745	7989	787	6	1048
P	65	577	3189	168	279
M	5	4	80	491	55
I	8663	1183	471	48	0

MIGRATION INDEX BY SMGC:

X	T	P	M	AVG
0.85288	0.69019	0.74544	0.77323	0.76544

```
****  MIGRATION REPORT  ****
   Quarter 5 to quarter 9
         ALC SA

NUMBER OF RECORDS PROCESSED FROM FILE A =  166439
NUMBER OF RECORDS PROCESSED FROM FILE B =  101067
TOTAL NUMBER OF ITEMS =  172622
MISMATCH INDEX        =   0.06118

BY SMGC IN A       134595   22239    8207    1398
BY SMGC IN B        84013   11989    4471     594

FROM\TO    X       T       P       M       O
 X       76152    2662     227      21   55533
 T        1834    8636     911       6   10852
 P          89     539    3209     178    4192
 M           8       1      48     363     978
 I        5930     151      76      26       0

MIGRATION INDEX BY SMGC:

    X         T         P         M        AVG
 0.90643   0.72033   0.71774   0.61111   0.73890

****  MIGRATION REPORT  ****
   Quarter 5 to quarter 9
         ALC SM

NUMBER OF RECORDS PROCESSED FROM FILE A =   91279
NUMBER OF RECORDS PROCESSED FROM FILE B =   78624
TOTAL NUMBER OF ITEMS =   96638
MISMATCH INDEX        =   0.05816

BY SMGC IN A        77698   10290    2976     315
BY SMGC IN B        65343    9590    3319     372

FROM\TO    X       T       P       M       O
 X       58689    2629     345      15   16020
 T        1611    6294     760       4    1621
 P          45     437    2046     116     332
 M           5       2      49     219      40
 I        4994     228     119      18       0

MIGRATION INDEX BY SMGC:

    X         T         P         M        AVG
 0.89817   0.65631   0.68750   0.69524   0.73430
```

Appendix D

Migration Statistics Reports

This appendix presents the output reports generated by the time-dependent analysis programs MIGSTATA and MIGSTATB. These both provide a number of statistics on the twelve quarter data from the San Antonio ALC.

MIGSTATA

MIGSTATA provides statistics on the migration habits of the various items in the system, both collectively and by management category. The data were filtered two ways in order to overcome some problems found in early runs. The first filter dumps any item which was not in the system for at least three quarters. This was done to achieve a more representative picture of the steady state nature of the system. There were 44897 items (about 20 percent of the total) dropped as a result of this filter. The second filter filled in single quarter drops in the data with the values from the previous quarter. This was done because there was an unusual number of items with only a single quarter missing, usually in the quarter associated with the twelfth project quarter (June 83 data). No cause for this could be found, but it was unlikely that the items would only be missing for the one quarter; hence the filter. The summary statistics and the frequency tables are used to determine if there are any patterns evident in the data.

**** MIGRATION ANALYSIS REPORT ****

PART A

NUMBER OF RECORDS PROCESSED = 217735
NUMBER OF RECORDS DUMPED = 44897
NUMBER OF ITEMS WHICH MIGRATED = 128009
NUMBER OF ITEMS ALWAYS IN = 54135
WHICH ENTERED & LEFT = 13675
WHICH LEFT & RE-ENTERED = 44019

NUMBER OF MIGRATIONS PER ITEM --
MEAN = 1.362478
VARIANCE = 1.336670
STD DEV = 1.156144

NUMBER OF QUARTERS IN SYSTEM PER ITEM --
MEAN = 9.708097
VARIANCE = 6.122159
STD DEV = 2.474300

NUMBER OF QUARTERS IN ALL CATAGORIES --
MEAN = 5.570385
VARIANCE = 15.115565
STD DEV = 3.887874

NUMBER OF QUARTERS IN SMGC X (PER ITEM) --
MEAN = 7.464604
VARIANCE = 14.512857
STD DEV = 3.809574

NUMBER OF QUARTERS IN SMGC T (PER ITEM) --
MEAN = 4.942082
VARIANCE = 10.877743
STD DEV = 3.298142

NUMBER OF QUARTERS IN SMGC P (PER ITEM) --
MEAN = 4.823008
VARIANCE = 11.357855
STD DEV = 3.370142

NUMBER OF QUARTERS IN SMGC M (PER ITEM) --
MEAN = 4.512156
VARIANCE = 9.136189
STD DEV = 3.022613

NUMBER OF QUARTERS NOT IN SYSTEM (PER ITEM) --
MEAN = 2.304147
VARIANCE = 1.023540
STD DEV = 1.011702

******   MIGRATION   FREQUENCY   COUNT   ******

MAX CELL COUNT =   59914
MIN CELL COUNT =   0
SUM ALL CELLS =   172838

NUMBER OF QUARTERS	COUNT
0	44029
1	59914
2	42447
3	17273
4	7220
5	1772
6	162
7	19
8	2
9	0
10	0
11	0

******   QTRS IN SMGC FREQUENCY COUNT   ******
ALL SMGCS

MAX CELL COUNT =   78087
MIN CELL COUNT =   2184
SUM ALL CELLS =   279517

NUMBER OF QUARTERS	COUNT
1	17554
2	78087
3	19850
4	15908
5	52441
6	11432
7	4534
8	2184
9	4189
10	8342
11	20967
12	44029

**** QTRS IN SMGC FREQUENCY COUNT ****
SMGC X

MAX CELL COUNT = 39846
MIN CELL COUNT = 1458
SUM ALL CELLS = 151644

NUMBER OF QUARTERS	COUNT
1	8973
2	5027
3	10300
4	9182
5	38829
6	7437
7	1695
8	1458
9	2852
10	7302
11	18743
12	39846

**** QTRS IN SMGC FREQUENCY COUNT ****
SMGC T

MAX CELL COUNT = 7913
MIN CELL COUNT = 527
SUM ALL CELLS = 34461

NUMBER OF QUARTERS	COUNT
1	4519
2	4683
3	4521
4	3276
5	7913
6	1625
7	1288
8	527
9	998
10	788
11	1528
12	2795

**** QTRS IN SMGC FREQUENCY COUNT ****
SMGC P

MAX CELL COUNT = 3213
MIN CELL COUNT = 173
SUM ALL CELLS = 13560

NUMBER OF QUARTERS	COUNT
1	2006
2	1965
3	1871
4	1107
5	3213
6	465
7	384
8	173
9	303
10	231
11	645
12	1197

**** QTRS IN SMGC FREQUENCY COUNT ****
SMGC M

MAX CELL COUNT = 825
MIN CELL COUNT = 21
SUM ALL CELLS = 2427

NUMBER OF QUARTERS	COUNT
1	346
2	319
3	370
4	172
5	825
6	39
7	33
8	24
9	36
10	21
11	51
12	191

****** QTRS IN SMGC FREQUENCY COUNT ******
NOT IN SYSTEM

MAX CELL COUNT = 66093
MIN CELL COUNT = 0
SUM ALL CELLS = 77425

NUMBER OF QUARTERS	COUNT
1	1710
2	66093
3	2788
4	2171
5	1661
6	1866
7	1134
8	2
9	0
10	0
11	0
12	0

DEMAND CHANGE INDEX COUNT FOR MIGRATING ITEMS

0	TO	1	=	4127
1	TO	10	=	1662
10	TO	100	=	3320
100	TO	1000	=	7473
1000	TO	10000	=	7553
10000	TO	INF	=	64493

DEMAND CHANGE INDEX COUNT FOR NO MIGRATION

0	TO	1	=	2307
1	TO	10	=	31252
10	TO	100	=	63196
100	TO	1000	=	142049
1000	TO	10000	=	109187
10000	TO	INF	=	75082

MIGSTATB

MIGSTATB provides additional statistics to that found in MIGSTATA. The data was divided into two parts, HIGH which includes all of the items in categories P and M, and LOW which includes all of the items in X and T. Only those records which were in the first quarter are considered.

The data were analysed to see how many items migrated from LOW to HIGH over the twelve quarter period, how many moved back down, and how many again returned to HIGH. The results of this analysis are shown in the first table. The remaining tables record how many of the original items in the given category have remained through the quarter shown. For this analysis, once an item leaves the category, it is no longer considered, even if it should come back in.

**** MIGRATION ANALYSIS REPORT ****

PART B

NUMBER OF RECORDS PROCESSED	=	217735
NUMBER OF RECORDS NOT IN FIRST QTR	=	63026
NUMBER OF RECORDS DUMPED	=	0
NUMBER OF RECORDS REMAINING	=	154709
NUMBER OF ITEMS WHICH STARTED HI	=	8970
NUMBER OF ITEMS WHICH STARTED LO	=	145739
NUMBER OF LOW MOVING TO HIGH	=	15337
NUMBER MOVING DOWN AGAIN	=	2414
NUMBER GOING UP ONCE AGAIN	=	2071

NUMBER OF ORIGINAL ITEMS REMAINING IN CATEGORY X

QTR	NUMBER REMAINING
1	125238
2	121664
3	119717
4	117901
5	110643
6	73061
7	67155
8	66480
9	66234
10	65344
11	58589
12	39846

NUMBER OF ORIGINAL ITEMS REMAINING IN CATEGORY T

QTR	NUMBER REMAINING
1	20501
2	19360
3	17652
4	16263
5	14680
6	7695
7	6492
8	5649
9	5611
10	4978
11	4323
12	2795

NUMBER OF ORIGINAL ITEMS REMAINING IN CATEGORY P

QTR	NUMBER REMAINING
1	7667
2	7173
3	6556
4	6096
5	5652
6	2792
7	2440
8	2213
9	2184
10	2029
11	1842
12	1197

NUMBER OF ORIGINAL ITEMS REMAINING IN CATEGORY M

QTR	NUMBER REMAINING
1	1303
2	1242
3	1175
4	1145
5	1097
6	315
7	291
8	281
9	272
10	261
11	242
12	191

APPENDIX E

ALC Major Mission Assignments

This appendix lists the major mission assignments of the five ALCs within the AFLC system. The source for the information is the Command Information Digest dated March, 1985 (2:GI 7 - GI 11).

Oklahoma City ALC (OC)

Systems/Programs

C-18A Aircraft
A-7 Corsair II
B-52 Stratofortress
B-1B
C-135 Stratolifter
C-137 Stratoliner
E-4 Advanced Airborne Command Post (AABNCP)
E-3A Sentry
AGM-69 Short Range Attack Missile (SRAM)
AGM-86 Air Launched Cruise Missile (ALCM)
BGM-109G Ground Launched Cruise Missile (GLCM)
B-52 Companion Trainer Aircraft (CTA)
AGM-109H Medium Range Air to Surface Missile (MRASM)
AGM-84 Harpoon
C-19 Aircraft
Advanced Cruise Missile
KC-10 Aircraft

Commodities/Aggregations

Aircraft Instruments
Aircraft Hydraulic Systems
Aircraft Temperature & Pressure Controls
Aircraft Jet Engines

Technology Repair Center for:

Aircraft:
A-7, B-52G, C-135, E-3

Aircraft Jet Engine/Components:
TF30, F101, CFM-46, F110, J57, F107, F108

Hydraulics/Pneudraulics

Oxygen Components

Automatic Flicht Control Instruments

Ogden ALC (OO)

Systems/Programs	Commodities/Aggregations
F/RF-4 Phantom II	Airmunitions
F-16 Fighting Falcon	Photographic and Reconnaissance Equipment
CIM-10 Bomarc	Aircraft Landing Gear Components
LGM-25C Titan	Rocket Engines
LGM-30 Minuteman	
AGM-65 Maverick	
MGM-118A Peacekeeper	
Flight Simulation Systems	
494L Emergency Rocket Communication System (ERCS)	

Technology Repair Center

Aircraft:
F/RF-4, F-16
Missiles:
AIM-4, AIM-9, AGM-45, AGM-65, AGM-69, AGM-86A, AGM-88, BGM-109G, GBU-15, CIM-10, LGM-25, LGM-30, AGM-109H, MGM-118A
Weapons
Airmunitions
Missile Components
Landing Gear
Photographic Equipment
Training and Simulation Equipment
Instruments
Rocket Engines

San Antonio (SA)

Systems/Programs

A/T-37 Dragonfly/Tweet
C-5 Galaxy
C-6 King Air
C-9 Nightingale
C-131 Samaritan
F-5 Freedom Fighter
F-106 Delta Dart
F-20
O-2 Skymaster
OV-10 Bronco
T-29
T-38 Talon
T-41 Mescalero
T-43
627A Advanced Ballistic Reentry System (ABRES)
Base and Installation Security System (BISS)
Ground Proximity Warning System
T-46
C-17
DOD Dog Center

Commodities/Aggregations

Aircraft Jet Engines
Aircraft Reciprocation Engines
Aircraft Ground Service Equipment
Aircraft Maintenance Equipment
Nuclear Ordnance Materiel
Life Support Equipment
Electronic Test Equipment
Automatic Test Equipment
Fuels, Lubricants, & Oils
Alarm and Signal Systems
Secure Communications
Air Force Watercraft
Modular Automatic Test Equipment

Technology Repair Center

Aircraft:
B-52D/H, C-5
Aircraft Jet Engines/Components:
F100, F404, T56, F109, TF39, GTE, T700
Electronic Support Equipment
Electro/Mechanical Support Equipment
Nuclear Components

Sacramento (SM)

Systems/Programs

A-10 Thunderstrike
C-12 Attache Aircraft
C-121 Constellation
F-104 Starfighter
F-105 Thunderchief
EF/F/FB-111
T-33 T-bird
CT/T-39 Saberliner
QF-100 Drone
MILSTAR Communications System
AFSATCOM
Space Transportation System
726 Defense Support Program
427M Cheyenne Mountain
Aircraft Battle Damage Repair
Fiber Optics

Commodities/Aggregations

Communications/Electronics
- Ground Electronic Control Equipment
- Meteorolgical Equipment
- Ground Navigation Aids
- Ground Electronic Command Systems
- Electronic Counter-countermeasure
- Surveillance and Warning Systems
- Ground Radio Communications
- Electical Control and Distributions Equip.
- Electrical Generators

Technology Repair Centers

Aircraft:
A-10, T/CT-39, F/FB-111, F-4, C-12, C-21
Aircraft Related:
Structural Members, Control Surfaces, Airframe Components
Electrical Components
Ground-Electronics
Hydraulics/Pneudraulics
Flight Control Instruments

Warner-Robbins (WR)

Systems/Programs

C-7 Caribou
C-123 Provider
C-130 Hercules
C-140 Jetstar
C-141 Starlifter
F-15 Eagle
Utility Aircraft
Helicopters
Remotely Piloted Vehicles
AIM-4 Falcon
AIM-7 Sparrow
AIM-9 Sidewinder
Advanced Medium Range Air-to-Air Missile (AMRAAM)
AGM-45 Shrike
AGM-78 Standard Arm
AGM-88 High Speed Arm
BQM-34 Firebee
Bare Base Equipment Program
C-20 Gulfstream
FIM/92A Stinger Weapon System

Technology Repair Center

Aircraft:
C-130, C-141, F-15
Airborne Electronics
Life Support Equipment
Propellers

Commodities/Aggregations

Airborne Radar Equipment
Airborne Communication/ Navigation Equipment
Airborne Electronic Warfare Equipment
Gunnery Equipment
Fire Fighting Equipment
Industrial Machinery
Vehicles
Propellers
Measuring and Hand Tools
ADP Systems
Personnel Safety Equip.
Bearings
463L Materials Handling System

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VITA

Captain John D. Kennedy was born on 7 August 1958 in Orange, California. He received a Bachelor of Operations Research from the United States Air Force Academy in 1980 and was commissioned a second lieutenant in the United States Air Force. His first assignment was to Headquarters Space Division in Los Angeles where he worked in the Space Defense Program office on ground system survivability. He remained there until his entry into the School of Engineering, Air Force Institute of Technology in June 1984.

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